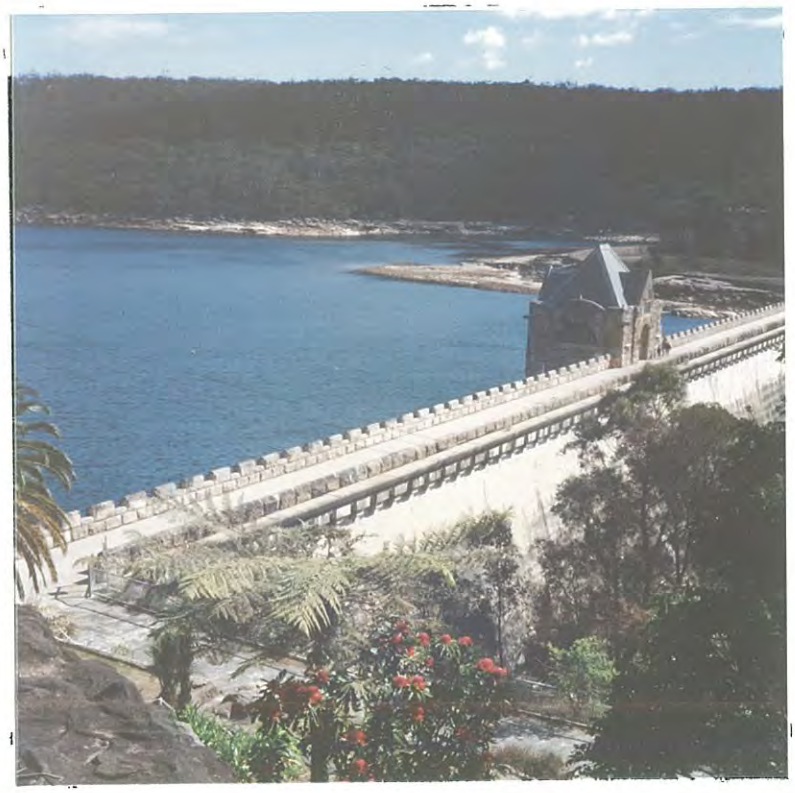
PROPOSAL TO LANDMARK THE

CATARACT DAM

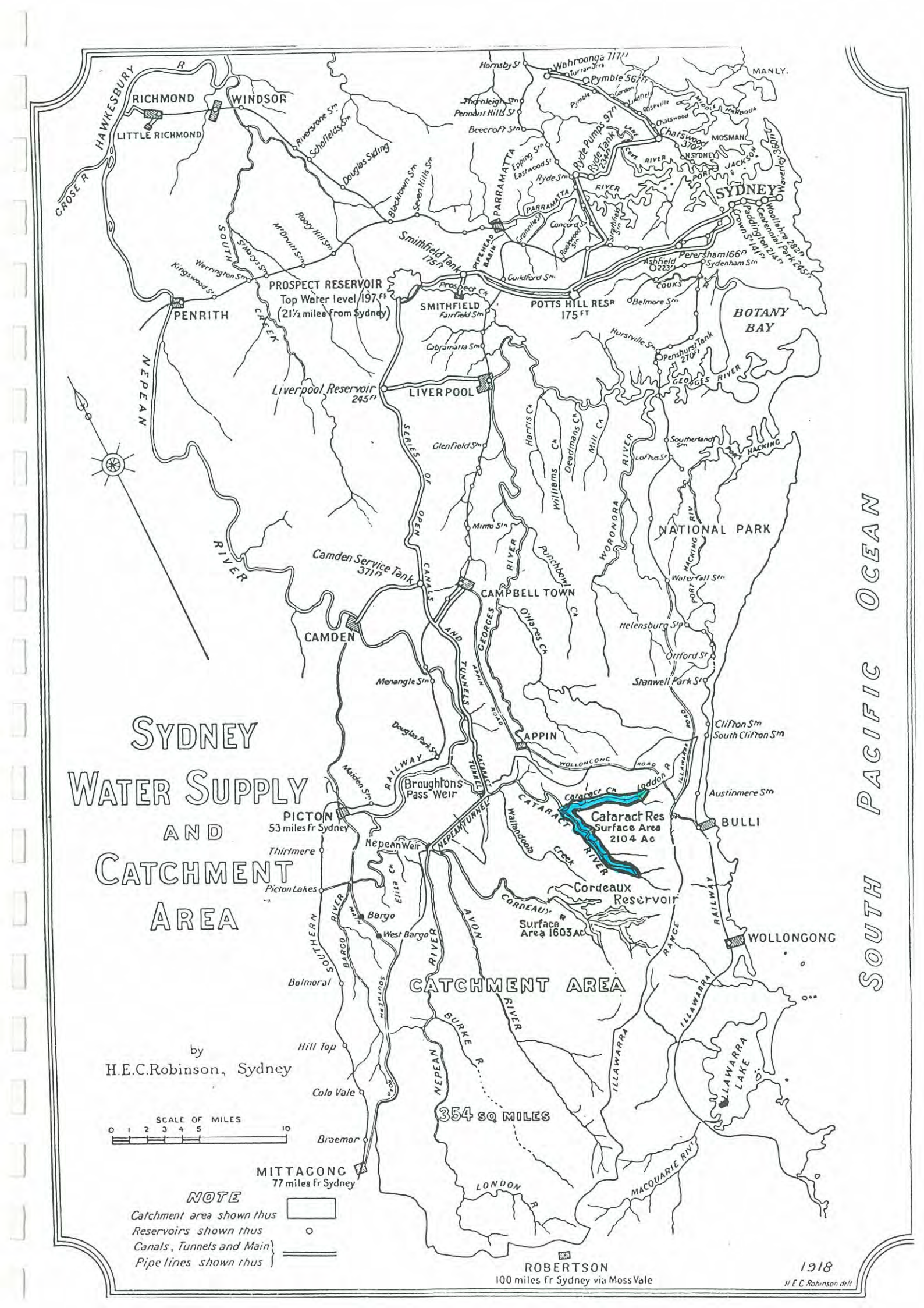
AS A

NATIONAL ENGINEERING LANDMARK



HERITAGE WEEK 1995
Plaquing Ceremony - Sunday, 9th April

Prepared for:
ENGINEERING HERITAGE COMMITTEE
SYDNEY DIVISION, IE AUST 1994
by Jon Breen, MIE Aust.


SYDNEY WATER SUPPLY AND CATCHMENT AREA
by H.E.C.Robinson, Sydney
SOUTH PACIFIC OCEAN
HAWKESBURY R.
RICHMOND
WINDSOR
LITTLE RICHMOND
GROSE R.
PENRITH
PROSPECT RESERVOIR
Top Water level 197 Ft
(21½ miles from Sydney)
SMITHFIELD
POTTS HILL RESR
175 FT
Smithfield Tank
175 Ft
PIPEHEAD BASIN
PARRAMATTA
Ryde Pumps 97 Ft
Ryde Tank 230 Ft
Chatswood 370 Ft
SYDNEY
MANLY
Waverley 300 Ft
Woollahra 282 Ft
Centennial Park 245 Ft
Paddington 214 Ft
Petersham 166 Ft
Ashfield 223 Ft
Penshurst Tank 270 Ft
BOTANY BAY
Liverpool Reservoir 245 Ft
LIVERPOOL
Camden Service Tank 371 Ft
CAMDEN
CAMPBELL TOWN
APPIN
NATIONAL PARK
Broughtons Pass Weir
PICTON
53 miles fr Sydney
Nepean Weir
NEPEAN TUNNEL
CATARACT TUNNEL
Cataract Res
Surface Area
2104 Ac
BULI
Cordeaux Reservoir
Surface Area 1603 Ac
WOLLONGONG
CATCHMENT AREA
Bargo
West Bargo
Balmoral
Hill Top
Colo Vale
Braemar
MITTAGONG
77 miles fr Sydney
354 SQ MILES
ROBERTSON
100 miles fr Sydney via Moss Vale
ILLAWARRA LAKE
SCALE OF MILES
0 1 2 3 4 5 10
NOTE
Catchment area shown thus
Reservoirs shown thus
Canals, Tunnels and Main Pipe lines shown thus
1918
H.E.C. Robinson delt

THE HISTORY, CONSTRUCTION, OPERATION AND MAINTENANCE OF CATARACT DAM

4.0 OPERATION OF THE DAM (cont.)

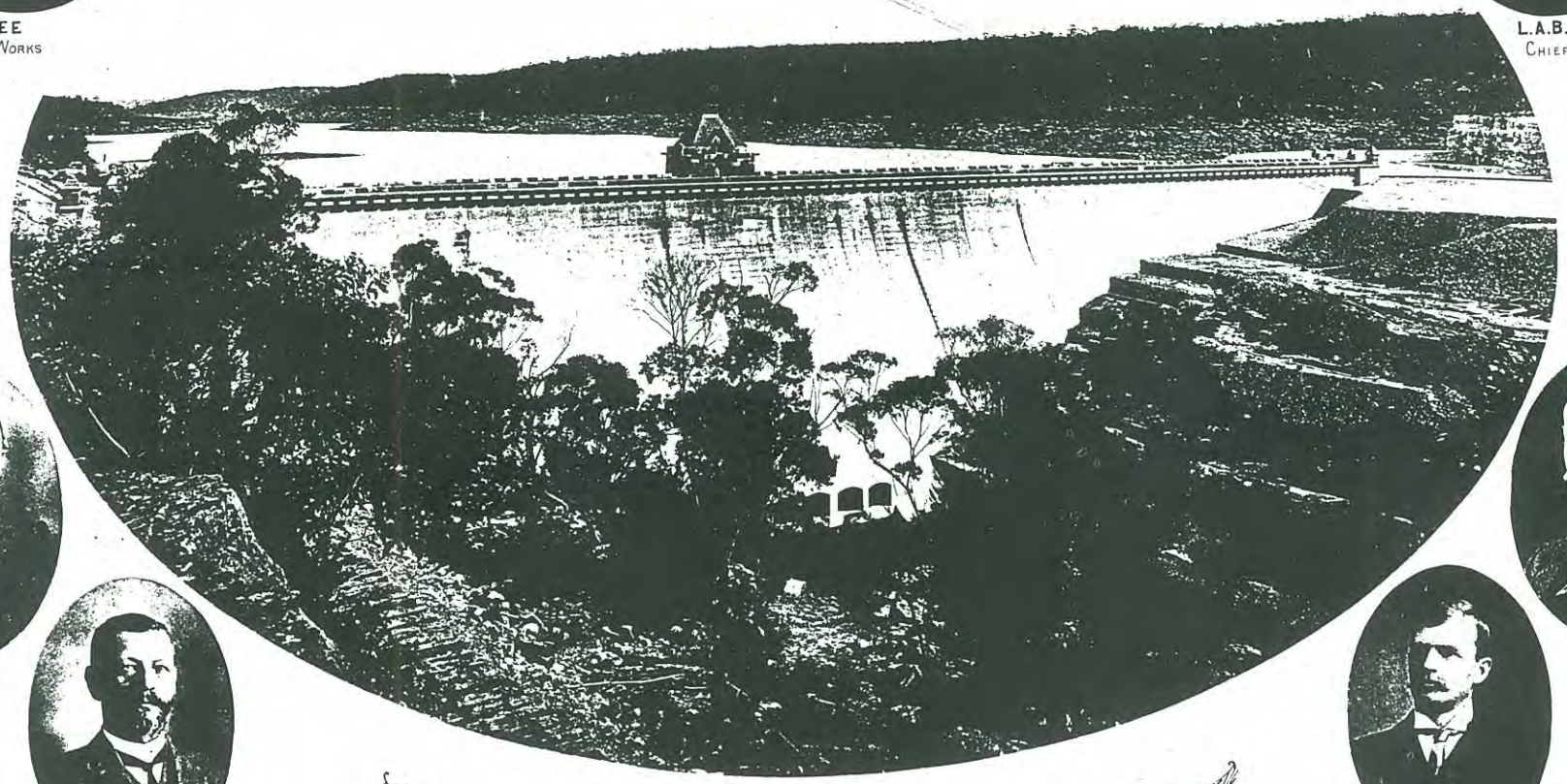
SYDNEY WATER SUPPLY

CATARACT DAM

NEW SOUTH WALES

THE HON. C.A. LEE
SECRETARY FOR PUBLIC WORKS

L.A.B. WADE M.INST.C.E.
CHIEF ENGINEER



W. LANE

CONTRACTORS

T. PETERS

E.M. DE BURGH M.INST.C.E.
SUPERVISING ENGINEER

J. SYMONDS
RESIDENT ENGINEER

1902 1907

1.0 INTRODUCTION

1.1 General

Date of Construction
1902 - 1907

Key Professional Personnel

Chief Engineer/Designer	L A B Wade
Supervising Engineer	E M de Burgh
Resident Engineer	J Symonds
President Water Board/Designer	T W Keele
Design Engineer	H H Dare
Under Secretary for Public Works	J Davis
Design Engineer	J J C Bradfield
Inspecting Engineer for NSW	C W Darley
Principal Assistant Engineer	A E Cutler
Chief Engineer for Water Supply, Victoria	S Murray
Secretary, Water Board	W C Holmes
Contractors	Lane and Peters

Government

Secretary for Public Works*	E W O'Sullivan (before 14 April 1904)
Secretary for Public Works*	W. Bennett (15 June - 29 August 1904)
Secretary for Public Works*	C A Lee (after 30 August 1904)

* The term Secretary was equivalent to Minister in colonial administrations.

Local Government
Lord Mayor of Sydney ..... T Hughes

Historical Summary
In the second Cataract Dam Royal Commission of 1905 it is reported in conclusion (para 393): *"that the Cataract Dam is the largest work of its kind in the Southern Hemisphere and that work of a similar character and magnitude had not previously been carried out anywhere in Australia".*

At the time of construction this was the first major masonry dam in Australia. In the Royal Commission (para 6) the Minister for Public Works charged that the designer Thomas Keele had *"misled, not only the (Parliamentary) Committee, but the Parliament of the country".*

The concept for Cataract Dam was conceived during the Sydney Water Commission of 1867-69 as part of the Upper Nepean Water Supply Scheme. The overall scheme had been proposed in the 1852 Water Commission which reported to the New South Wales Legislation Council. (The state of New South Wales did not get self government until 1855). It was the first major storage of the Upper Nepean Water Supply Scheme, that scheme being constructed between 1880 and 1888, and utilised on a temporary basis from 1886. The Upper Nepean Scheme was a *"run of the river scheme"* with the only substantial storage being Prospect Reservoir (Historic Engineering Marker, 1994). That scheme operated until 1902 without change, until the extreme drought of 1902. That drought was a mainland wide drought in that it also effected Western Australia and Queensland. The dams previously built in Victoria, minimised the effect of the drought on that state.

With the intensity of the 1902 drought construction was commenced with some haste. This in turn laid the seeds for substantial controversy before the project was completed. There were changes of Minister, indeed a change of Government during construction. The third Minister initiated 2 Royal Commissions the first with an interstate Chief Commissioner. The first was to determine the final height of the dam, the other was to determine the reasons for substantial cost over-runs. The President of the Water Board Thomas Keele (who has also been one of the designers) was exonerated but his term was not extended in 1908 and he was transferred to a lesser position as President of the Sydney Harbour Trust. The methods of construction and the technologies introduced came to be used at other dams throughout Australia. These methods were rigorously assessed during the 15,863 paragraphs of evidence during the 2nd Royal Commission of 1905. The dam is not monolithic concrete as it appears when viewed from downstream. It is in fact cyclopean masonry, in this case sandstone with each of the quarried sandstone blocks weighing from 2 to 4½ tons. The blocks were bedded in mortar (ie sand cement mix) and the gaps between the blocks were filled with sandstone concrete. The upstream face was built of moulded pre-cast bluestone concrete blocks in a brickwork pattern.

Even though Keele died in 1927 his name was mentioned in evidence in another Royal Commission in 1933 ie into the rupture of the Sydney Pressure Tunnel which was built to upsize a part of the original Upper Nepean Scheme. The small island near the dam wall is named after him. The power station was near the island, along with the basalt moulding yard and part of the railway. A

Metropolitan Board of Water Supply and Sewerage.

PUBLIC NOTICE.

Owing to the continuance of the **unprecedented drought** from which the State of New South Wales in general has been for some months suffering, the water in the Storage Reservoir at Prospect available for supply by gravitation, will within a few days have been consumed, when steps will require to be taken to raise water from below gravitation level by means of pumping, to the inlet level of the canal.

Machinery (in duplicate) has been installed to perform the service, and by this means the water supply to the City and Suburbs will be maintained.

As it is difficult, and indeed impossible, to foretell the length of time the present dry season may continue, the Board is of opinion that the time has now arrived when an **appeal** should be made to the **Citizens** in the interests of the common good, and in order **to avoid** the necessity for resorting to **an intermittent system** of supply, which would create grave inconvenience, to exercise the **strictest economy** in the **use of water** in every direction.

The Public are therefore earnestly requested to co-operate with the Board in meeting **this emergency** by examining the water fittings of their premises and having any leakages attended to forthwith, by **curtailing** the use of **water** for all household and domestic requirements, particularly for **plunge baths,** and by **abstaining** from using water for **gardens, lawns, ornamental fountains and such like purposes.**

The Board feels confident that the good sense and judgment of the Citizens will ensure the success of its appeal, and render recourse to other and sterner measures altogether unnecessary.

By order of the Board,

WILLIAM HOLMES,
Secretary.

Board's Offices,
341 Pitt Street,
24th May, 1902.

method to pipe pressurised Cataract Dam water to Sydney was also discussed during the 1933 Royal Commission, (Ref. Appendix A7).

The fact that Cataract Dam was built to its present height in 1907 was based upon the recommendation of the NSW Joint Parliamentary Standing Committee on Public Works (JPSCPW). The committee reviewed all major projects in NSW between 1889 and 1940. The Joint Parliamentary Select Committee into the Sydney Water Board 1993, recommended that very same committee be re-activated as a Parliamentary Environmental Works Committee since the legislative framework is still in place.

The Water Commission of 1852 led to the Botany Water Supply Scheme. The Sydney Water Commission of 1867/69 led to the Upper Nepean Scheme, (aided by the Clark Commission of 1876/77). The 1902/3 Royal Commission resulted in Cataract Dam and later the other Upper Nepean Dams. Similarly the 1884/87 *'Conservation of Water'* Royal Commission eventually led to Burrinjuck Dam and the Hume Weir. (The first Royal Commission in Britain reported in 1887 - (Ref. Butler A).

1.2 Statement of Significance

Cataract Dam at the time of construction was the largest concrete/masonry dam ever built in Australia and was described in the 2nd Royal Commission of 1905, as *"the largest work of its kind in the Southern Hemisphere and that work of a similar nature has not previously been carried out anywhere in Australia".*

There was great controversy during construction, mainly on the matter of cost. That led to the two Royal Commissions of 1905 with the taking of over 15,000 paragraphs of evidence. That evidence questioned and recorded the decision making process prior to, and during, construction (Ref. Appendix A6). The controversy was so intense that A B 'Banjo' Paterson wrote a poem about it called *"The Dam that Keele Built".* The design process had involved the inspection of large dams being constructed in England, France and the U.S.A. by engineers such as L.A.B. Wade, E.M. de Burgh and C.W. Darley. These people had become world leaders in dam technology through their work on smaller dams but Cataract was their first major test. Wade and de Burgh went on to promote and build many large dams, both for drinking water and irrigation purposes, such as the Hume Weir on the River Murray.

It was the first major project which utilised electricity which was generated on site by the burning of timer which had been cleared from the inundation site. It was capable of drawing water off at one of four levels so as to obtain the optimum quality of water. At later drinking water dams this facility was extended to be able to extract a band of water from any level. There are no access galleries in the dam wall (except for a short gallery to provide for the township water supply).

The dam has been upgraded significantly over the years by the use of the most modern technology, whilst its intrinsic charm has been retained. It has withstood droughts, floods, fires and wars and its builders and machinery went on to other dams such as Burrinjuck and indeed its builders went on to many other projects, with Cataract remaining as a yardstick.

The Upper Valve House is the most obvious heritage feature of the dam. The Water Board has a linen plan showing that it was, in fact, to be much more ornate, looking something like a cathedral.

1.3 **Nomination Form** (see over)

Commemorative Plaque Nomination Form

Date 5 November 1994

To :
Commemorative Plaque Sub-Committee
c/- Local Division office of the Institution
and its Heritage Committee/Panel

From Engineering Heritage Committee
Sydney Division

Nominating Body

The following work is nominated for a :-

* National Engineering Landmark
* ~~International Engineering Landmark~~
*(delete as appropriate)

Name of work Cataract Dam

Location, including address, and map grid reference if a fixed work

Appin, NSW, on Cataract River,
just below junction with Cataract Creek

Owner Water Board, (Sydney, Wollongong, Blue Mountains)

The owner has been advised of the nomination of the work and has indicated

(attach copy of letter if available) Copy of request attached.
Copy of reply attached.

Access to site Road

Future care and maintenance of the work Under auspices of NSW Dam Safety Act

Name of sponsor

For a NEL, is an information plaque required ? YES

Chairperson of Nominating Committee

Chairperson of Division Heritage Committee/Panel

ADDITIONAL SUPPORTING INFORMATION

Name of work . . Cataract Dam

Year of construction or manufacture . . 1902-1907

Period of operation . . . . 1907 - present

Physical condition . . Excellent

Engineering Heritage Significance :-

Technological/scientific value . Milestone in water quality and construction technology.

Historical value . Keystone of Sydney's water supply and subsequent development.

Social value . . Staff went on to build a series of major irrigation/drinking water dams.

Landscape or townscape value . . Outstanding Valve House and other buildings

Rarity . . Later dams were less ornate

Representativeness . . Major symbol of Upper Nepean Scheme.

Contribution to the nation or region . Experience carried through to projects throughout Australia.

Contribution to engineering . Largest work of its type in the Southern Hemisphere.

Persons associated with the work . . LAB Wade, EM deBurgh, CW Darley, HH Dare, JJC Bradfield, S Murray, TW Keele.

Integrity . Excellent

Authenticity . Heritage maintained despite extensive upgrading

Comparable works (a) in Australia . Mundaring Weir (Kalgoorlie Gold Fields) NEL 1987 (WA)

(b) overseas . . Designers visited North America, Britain & France. (possible Dambuster's association)

Statement of significance, its location in the supporting documentation . Section 1.2

Citation (70 words is optimum) . See attached Section 1.4

Attachments to the submission (if any) . Photographs & Appendices A-C

Location of plaque (if not at site)

The Institution of Engineers, Australia

ESTABLISHED 1919 · INCORPORATED 1926
INCORPORATED BY ROYAL CHARTER 1938

SYDNEY DIVISION

ENGINEERING HERITAGE COMMITTEE

EAGLE HOUSE,
118 ALFRED STREET
MILSONS POINT 2061

TELEPHONE: 929 8544

ALL CORRESPONDENCE
SHOULD BE ADDRESSED
TO:
THE SECRETARY,
BOX 138, POST OFFICE,
MILSONS POINT, 2061

Please reply to
57/6 Hale Road
Mosman NSW 2088
11.3.1994

Telephone: 909 2588

Mr Reece McDougall
Senior Environmental Officer
Water Board, Level 15
Bathurst and Pitt Streets
Sydney 2000

Dear Mr. McDougall,

The Engineering Heritage Committee of the Sydney Division of the Institution of Engineers, Australia discussed conferral of an Historic Engineering Marker on the Cataract Dam, and considered that it might be appropriate to do so during Heritage Week in 1995. As you may know, there is an appreciable amount of preliminary work to be done, and I am writing to you to ascertain whether you are in principle agreeable to this proposal.

Yours sincerely,

Copies: Mr. Bowie, Prof. Fraser.

WATER BOARD
SYDNEY - ILLAWARRA - BLUE MOUNTAINS

Form 2-84 (Feb. '93 A) Water Board Print.
heritage.mem

Reference _____

MEMORANDUM

To: MANAGING DIRECTOR

From: EXECUTIVE OFFICER TO BOARD

Subject: **PROPOSED RECOGNITION OF CATARACT DAM - HERITAGE WEEK, 1995**

The Institution of Engineers proposes to recognise Cataract Dam as a National Engineering Landmark during Heritage Week in 1995. A submission to support the nomination has been prepared.

The attached memo from the Project Manager, Heritage Services indicates that the Upper Limiting Fee for the project would be $4,000. Please confirm:

1. that the project may proceed, subject to the co-operation of the Institution of Engineers; and

2. whether you (or the Chairman) would wish to be involved in the ceremony at Cataract planned for Sunday, 9 April, 1995.

G Henstock

Geoff Henstock
21.11.1994

Yes I do both.

21/11/94
Managing Director

MEMORANDUM

TO: Geoff Henstock
Executive Officer to the Appointed Board

cc: Reece McDougall, Manager EMG, AWT EnSight
Andrew Speers, Manager Environment
Jeff Cameron, Director Bulkwater & Waste Water
Ron Quill, Manager Bulk Water

FROM: Jon Breen
Project Manager, Heritage Services

DATE: 16 November 1994

SUBJECT: **HERITAGE WEEK 1995, SUNDAY 9 APRIL, CATARACT DAM**

Since receipt of the attached letter from the Institution of Engineer's Australia, dated 11/3/94, a draft 50 page submission has been prepared for the Institution seeking approval for National Listing. Part of that process is for the Board as owner to signify its agreement to the ceremony taking place. The Institution has tentatively listed it with the Heritage Week organisers as the Institution's major function during Heritage Week. These ceremonies have previously taken place at Prospect Reservoir in April 1994 and at Busbys Bore in February 1988.

Cataract may achieve National Listing because of its national significance. In the 2nd Royal Commission of 1905 it was described thus: "the largest work of its kind in the Southern Hemisphere, and that work of a similar character and magnitude has not previously been carried out anywhere in Australia", para 393. The basis for the Royal Commission was that the Minister, Charles A. Lee described the then Board's President Thomas Keele as: "showing conclusively that he has misled not only the Committee, but the Parliament of the country", para 5. The controversy was so intense that AB (Banjo) Patterson wrote a poem about it.

Would you please advise if the Managing Director is prepared to approve this project in a similar way to your memo dated 23/11/93 for Prospect Reservoir. The ULF would be $4,000, and the project would be managed by Environment Branch.

Jon Breen
Jon Breen

1.4 Proposed Words on Information Plaque:

INFORMATION PLAQUE

Cataract Dam

Lane and Peters completed this sandstone-block masonry dam faced with basalt concrete between 1905 and 1907, for the NSW Public Works Department, to a design by L.A.B. Wade and T.W. Keele. It was the first large dam for city water supply in Australia, the fourth largest of its type in the world and the first of the four Upper Nepean storages that provided a buffer against the effect of long droughts.

Dedicated by the
INSTITUTION OF ENGINEERS, AUSTRALIA
and
THE WATER BOARD

CATARACT (COUNTRY) (Town or District)	CATARACT DAM WALL plus bywash, valve house, Water Board Official Quarters (1910) Curtilage to include: adjacent gardens, parklands, picnic grounds, pathways and four cottages. (Name or Identification of Listing)	Cataract Rd at Lake Catara 84 km South of Sydney, near Appin, across Cataract River NSW Topographic 1:25000 1st Edition BULLI 9029-11- Dam Wall GR 977061-GR97405 (Address or Location)
Post Code 2560 Local Govt Area Shire of Wollondilly		
Author of Proposal M. Simpson		
Date of Proposal 7/5/85		
Suggested Listing Category CLASSIFIED	Bibliography Aird, W.V. The Water Supply, Sewerage and Drainage of Sydney. Halstead Press Pty Ltd Kingsgrove NSW 1961. Commemorative Volume, Sydney Water Supply and Sewerage 1788 to 1918, Sydney. 1918.	Owner and Address M.W.S. & D.B. cnr Pitt and Bathurst Streets, SYDNEY NSW 2000
Committee (Trust Use) IAC		
Council (Trust Use) APPROVED 22/7/85		

Description — Briefly cover the points on the following check list where they are relevant and within your knowledge.

Style
Construction
Use
Architect/s
Builder/s
Date of Construction
Present Condition
History
Owners
Boundaries of proposed listing

The Cataract Dam, completed in 1907, was the first of four water supply dams built for Sydney and was constructed to develop the Upper Nepean catchment area.

Background History

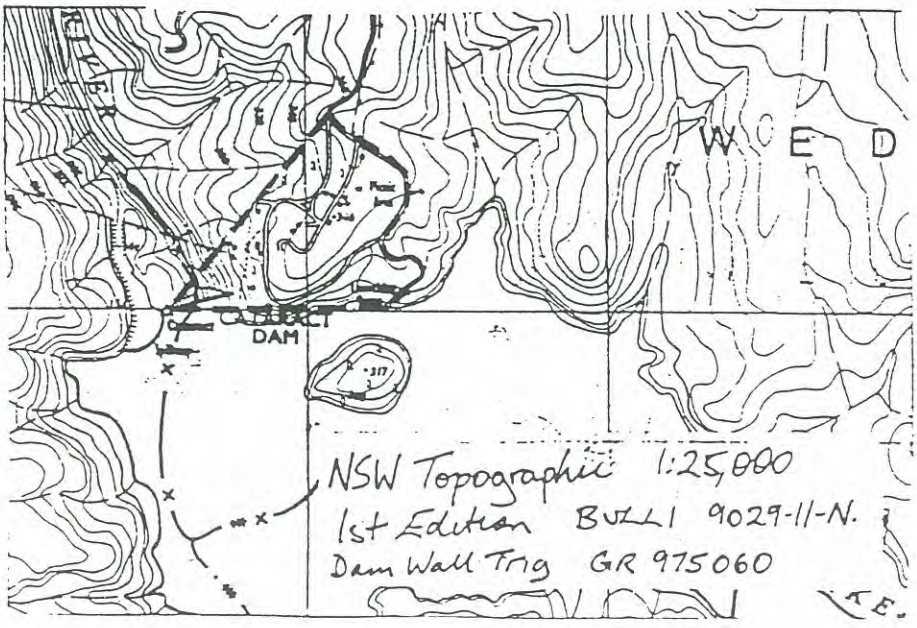
The Upper Nepean scheme was commenced in 1880 after it was realised that the Botany scheme was insufficient to meet Sydney's water supply needs. The Nepean project consisted of the construction of a weir across the Nepean River to divert water into a tunnel, 4½ miles (7.2 km) long, to the Cataract River, where a second weir at Broughton's Pass diverted the flow of the rivers, Cataract, Cordeaux, Avon and Nepean, into another tunnel. The first of a 35½ mile (51.2 km) long chain of open canals, pipe aqueducts and tunnels, know as the Upper Canal, ending at Prospect Creek, where an earthern dam was built, known as Prospect Reservoir.. From here, via a second open canal, the Lower Canal, the water was carried to "Pipehead", then through pipes for distributio to the city.

Continued on attached sheet...

Reasons for listing

Cataract Dam is very significant in that it was a major step towards the ultimate provision of a reliable water supply for Sydney. It was the first large water supply dam to be built in Australia, as well as being the first la cyclopean masonary dam in Australia. Furthermore, during its construction, extensive use was made of electricity on site, and production line techniques for the quarrying of stone blocks were used for the first time.

Sketch plan and photos
Attach additional photos if any.



CATARACT DAM WALL

Description continued ...

This original Nepean scheme was estimated to be capable of supplying the needs of a population up to 540,000 people. By 1902, Sydney's population had grown to 523,000 and a severe drought caused the water level in Prospect Reservoir to drop to below the limit of gravitational flow to the Lower Canal. This drought was the worst experienced by the Water Board since its inception in 1888. Rigorous restrictions were imposed, garden hoses were banned and even watering by watering-can was prohibited in the latter stages of the drought.

The seriousness of this position moved the Government, in March 1902, to appoint a Royal Commission to inquire into and report upon the Sydney water supply system. (The Water Board, nevertheless, had been searching for suitable sites for impounding water over the previous few years). The main recommendation of the Commission was that a storage dam be constructe to a point just below the junction of Cataract Creek with Cataract River. The Act authorising the construction of the dam was passed in 1902, and provided for a wall 160 feet (48.7m) high.

Construction of the Dam

The dam was built by the Public Works Department and the construction contract was let to Messrs Lane and Peters. E.M. de Burgh, then the Principal Assistant Engineer for Rivers, Water Supply and Drainage, was given special responsibility for the construction.

By June, 1903, much of the area to be submerged had been cleared of timber and by the end of the year the foundation excavations were in progress. The dam was built of cyclopean masonry composed of sandstone blocks weighing from two to four and a half tons. These were quarried at the site and bedded in a cement mortar. The vertical joints were filled with basalt or sandstone concrete.
The upstream face consisted of basalt concrete moulded blocks set in a cement mortar. The downstream face was of basalt concrete, six feet (1.8m) thick in the lower section and three feet (0.9m) thick in the upper levels. There were two lines of 48 inch (122 cm) diameter pipes which passed through the dam and discharged water into the river. The flow is controlled by a Larner Johnson needle valve.

The dam wall was given a decorative finish. The upstream parapet was castellated with sandstone blocks while the top of the downstream wall was corbelled in concrete. In about the middle of the dam wall stands the valve house. This is finished in quarried sandstone blocks with ashlar coursing. It features a steeply pitched slate covered pipped roof topped with finials and gables at either side.

The total cost of construction of the dam was 329,136 pounds ($658,272) when the dam was handed over to the Metropolitan Water Sewerage and Drainage Board. The reservoir was filled to capacity for the first time on the 13th January, 1911. However, it was realised that the spillway should be widened to avoid the risk of floodwaters overtopping the wall. This work was completed in 1915.

During construction of the dam extensive use was made of electricity on site, and production line techniques for the quarrying of stone blocks were used for the first time.

CATARACT DAM WALL

Description continued ...

Summary of the Specifications of the Dam

Date of construciton: 1902 - 1907
Masonry in wall and spillway: 148,000 cu. yds (113,220 cu. m).
Length of dam: 811 ft (247.2m)
Length of bywash: 684.5 ft (208.6 m)
Width at base: 156 ft (47.6m)
Width at crest: 16.5 ft (5m)
Greatest depth of water: 150 ft (45.7m)
Full supply level: 950 ft above sea level (289.5m)
Area of lake: 2,104 acres (851.5 ha)
Capacity: 20,743 million gallons (94,298 million litres)

The water from Cataract Dam is discharged as required into the Cataract River downstream to Broughton's Pass. There it is diverted by another weir into Cataract Tunnel, 2 miles (3.2 km) long, the first structure of the Upper Canal by which it is conveyed to Prospect Reservoir.

Also to be included in this classication is the Cataract Dam Official Quarters, situated close to the dam wall at the northern end. This single storey Federation house was built in 1910 for the use of Water Board staff during construction of the dam. It is built of ashlar masonry quarried on the site and features a verandah at the front with white painted timber posts with curved brackets and gabled entrance way. When built the house contained a board room, offices, four bedrooms and a kitchen. Over the years it provided accommodation for inspecting officers and important visitors. Today it is still used by the Water Board and can now provide sleeping accommodation for 12 people.

The gardens around the house are landscaped and the garden beds edged with sandstone. Also made of sandstone is a detached garage and two amenity blocks. Surrounding the garden is a castellated sandstone fence with decorative entrance posts. A further three sandstone cottages are located nearly as well as a brick cottage.

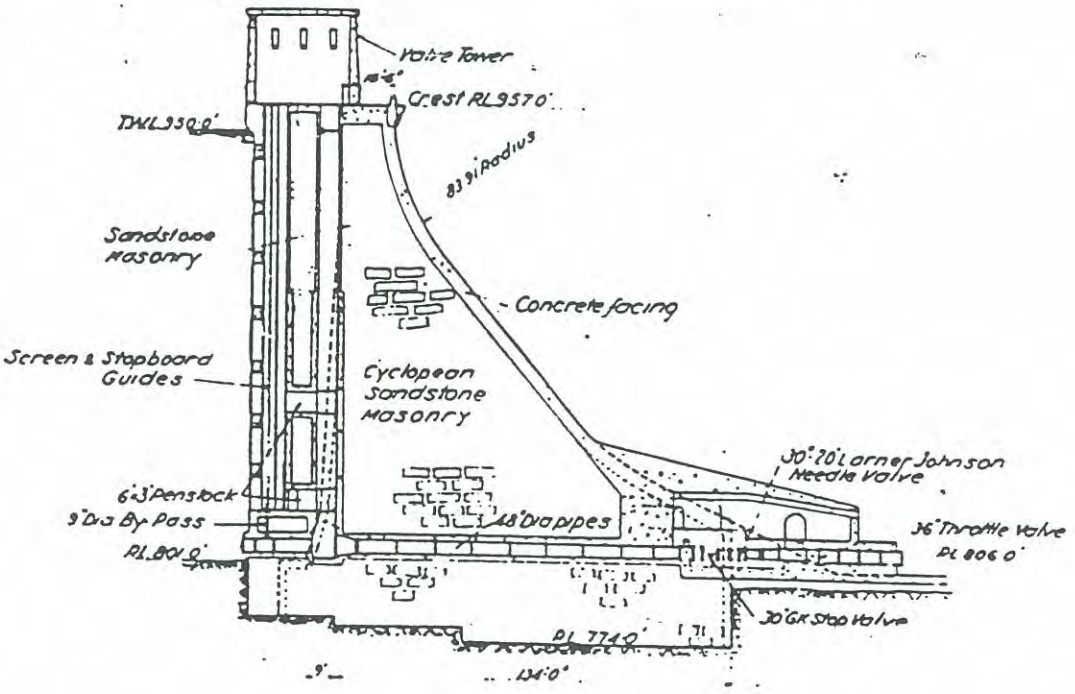
The Cataract Dam site is a very popular tourist attraction. The public area surrounding the dam is beautifully maintained by the Water Board and a large picnic area, shelter sheds, fireplaces and playground area are provided. These are also attractive gardens and bushwalks.

Boundary and Curtilage

Classification to include Dam Wall, Official Quarters and grounds defined by line from dam wall trig (9029-11-N GR 975060) to road junction at entrance to picnic area (GR 981066) around vehicle track to landing area (GR983060) and line projected back to dam wall trig.

Owner and Local Government Authority notified Form letter 1AC 2a 7/8/85 Rm
LGA 10/4/86 Rm

CATARACT DAM IN CROSS-SECTION



CATARACT

From: Aird, W.V. The Water Supply, Sewerage and Drainage of Sydney. Halstead Press, Pty Ltd. Kingsgrove, N.S.W., 1961.

2.0 THE HISTORICAL BACKGROUND

2.1 The Need for the Dam

2.1.1 General

The history of water supplies for Australian cities has often involved major problems and particularly so for Sydney. There is great variation between maximum flow and minimum flow. Droughts are intermittent and sometimes last for years. Historically 1789 and 1790 were very dry whilst 1810 and 1811 have been described as drought years. There were further droughts in the mid 1860's, in 1886, 1895-1902 and 1904-1910.

2.1.2 Before the Upper Nepean Scheme

The first water supply scheme for Sydney was the Tank Stream. Initially it was a "run of the river" scheme. However later square stone tanks were hewn out of the rock to provide storage for the fledgling city. Pollution of the scheme drove the settlers to a new scheme from the nearby Lachlan Swamps. That area is now known as Centennial Park, the place where the Federation of Australia was marked on 1st January 1901. Water was transported to the city by a tunnel which was known as Busby's Bore, (National Engineering Landmark, February 1988). At times of floods, spillover water from the Lachlan Swamps went into the Botany Swamps.

The Lachlan Swamps scheme was failing to meet the requirements of the expanding city so that in 1840 a timber dam was built on the Cooks River at Tempe near the present Princes Highway to form a water supply dam. A canal was to be built to take water to the city. However on completion it was found that high tides caused salt water to infiltrate back into the drinking water so that the scheme was abandoned as a drinking water dam.

The next scheme was from the Botany Swamps. This involved a series of low dams. The water drained towards Botany Bay and a steam pumping station was built in 1858 to pump the water back to Crown Street near to the city. The Crown Street Reservoir was built in 1859 and is still in use to-day.

The Botany scheme continued in operation until 1888 when the Upper Nepean Scheme became fully operational. In 1886 the situation was so desperate that a temporary

scheme was devised by Hudson Bros (the fore runner of Clyde Engineering) to bring Upper Nepean Water to Botany by means of temporary piping and flumes.

2.1.3 Details of the Upper Nepean Scheme

The Upper Nepean was permanently commissioned in 1888.

The Upper Nepean Scheme involved a river catchment system almost 60 miles away from the city. Water from this 354 square mile catchment was to be transferred by a series of canals and pipelines. It involved:

(a) A weir across the Nepean River at Pheasants Nest (Near Wilton). The weir would take water from the Nepean, Avon and Cordeaux Rivers.

(b) That water is diverted into a 5 mile rock tunnel (the Nepean Tunnel) and discharges into a similar weir at Broughton's Pass (near Appin) on the Cataract River. Similarly the combined waters flow into the Cataract Tunnel for about 1 mile when they reach the 40 mile long Upper Canal (Upper because upstream of Prospect Reservoir). The Upper Canal consists of rock tunnels, brick lined tunnels, aqueducts and open channelling of varying shapes (depending on the topography) all the way to Prospect Reservoir.

(c) Prospect Reservoir (HEM 1994) has a capacity of 12,000 million gallons.

(d) The Lower Canal (HEM 1994) took water from Prospect to Pipehead (the Head of the Pipe).

(e) The 72 inch pipe then took water to Potts Hill Reservoir and in turn to Crown Street Reservoir via a 48 inch main. (Crown Street was originally part of the Botany Scheme.)

The scheme was supervised by E.O. Moriarty, as Engineer-in-Chief for Harbours and Rivers. His replacement in 1889 was Cecil William Darley. Darley constructed numerous dams throughout NSW for country water supplies. He effectively became the *"Father of Dams"* in NSW. When he retired in 1901 that mantle was carried on by L.A.B. Wade who was assisted by E.M. de Burgh.

2.2 The Need for the Dam

Cataract Dam was desperately needed before it was constructed and after it was built it did not fill completely for a further 4 years.

The Upper Nepean Scheme involved a relatively large catchment 354 square miles but no large storage. The only substantial storage was Prospect Reservoir. In 1902, as a result of there being no dam, additional to Prospect Reservoir, various Emergency Schemes had to be built. The Upper Canal was originally supplied by "run of the river" water from the Nepean, Avon, Cataract and Cordeaux Rivers. With these sources dry, a temporary weir, constructed on the Nepean River at Menangle, ponded sufficient water for pumping (via an electric pumping station) up to the Upper Canal. Had this scheme in turn run "dry", pipes had been purchased to build a pipeline from Penrith to Prospect Reservoir to pump water directly to Prospect. A temporary weir had been built at Penrith. Although the Menangle Scheme was built and tested, it was never used because it rained a few days later. A copy of 1902 Public Notice has been included within the Introduction.

2.3 Various Proposals

The Royal Commission, initiated in 1902, issued 3 reports. The first issued on 28 April 1902 dealt with general water saving matters.

The 2nd report issued 7 July 1902 *"recommended the urgent attention of the Government to the immediate necessity of at once taking steps to provide additional storage".*

The report dealt with:

Cataract River (2 sites)

(a) A concrete dam near Appin Falls

(b) A concrete dam a little below the junction of the Cataract Creek with the Cataract River.

Cordeaux River:

"There are 2 good sites on this river. The survey of the upper one is completed and the lower one is in progress."

Nepean Dam

"A survey of a reservoir at the "Chain of Ponds" shows that a concrete dam retaining 140 feet of water would impound 7,500,000,000 gallons".

Other Sites

".....good sites on the Avon River and other remote portions of the catchment area".

The Commission further stated:
"We have satisfied ourselves from the evidence that the average annual quantity of water passing to waste over the weirs would, if it could all be impounded, be sufficient to supply many times over the present yearly consumption of Sydney". (The weirs mentioned are Pheasants Nest and Broughton's Pass.)

The report then sets out to determine the proper amount of storage to be provided. *"Consideration must, of course, be given to the question of the probable increase in population of Sydney and suburbs and the increase in the consumption of water.*

The increased consumption per head from 27.5 gallons in 1888 to 44 gallons in 1901 may be attributed to a variety of causes, such as increased use of water for baths (especially plunge baths), gardens and manufactures. Experience in other cities has shown that the consumption per head may still further increase beyond the 44 gallons referred to above.

We are therefore of the opinion that in providing for the future requirements of Sydney a consumption of 60 gallons per head should be allowed. The diagrams which have been produced in evidence show the flow of the Cataract River and the water which could have been impounded during the last fourteen years and they prove that in order to cope with the daily supply of 40,000,000 gallons it would be necessary to provide a storage of 6,500,000,000 gallons in addition to that in Prospect. We therefore consider the present storage should be supplemented by a dam to be erected on one of the rivers on the catchment area, capable of holding 7,000,000,000 gallons, and that such additional storage would meet the requirements of the population up to 1912; or for at least ten years."

The surveys were not sufficiently advanced to allow comparison of erecting dams at various sites (except for Cataract), but recommended that the first dam should be erected on the Cataract River because it had the following advantages:

a) Accessibility
b) Closeness to the Upper Canal off-take therefore less loss by soakage and evaporation

c) An enlargement of the slightly smaller Nepean Tunnel could be postponed using Cataract Dam water to maximise flow in Cataract Tunnel and in turn in the Upper Canal. The cost would be £126,000, ie $252,000.

The recommendation went much further than just storage. It was particularly modern in its concept, to quote: *"ECONOMY IN THE USE OF WATER".*

It is the duty of authorities to make the most searching enquiries into all causes of waste, fully 40% of the total supply is not only not paid for, but its consumption is not satisfactorily accounted for. We recommend that the attention of the Board be directed to the remarkable results recently recorded in England in connection with the use of wast water meters and the testing by stethoscopes of the flow in mains at night. It has been shown how, after the adaptation of these methods, the consumption per head in certain important cities in England has been reduced by fully one third (vide a paper by Mr E Collins and the discussion thereon reported in volume 117 of the Minutes of Proceedings of the Institution of Civil Engineers).

We recommend the adoption, wherever possible, of meters.....

It is evident that excessive quantity of water is used for street flushing ..... Municipal Authorities should be urged to adopt the most improved methods of street watering, such as have long been in use in important cities in Europe.

Mining Under Catchment Area:
The Chief Inspector of Coal Mines considers that the cover over the coal measures on the catchment area varies from 300 feet to 1,200 feet and that there is no probability of loss of water as the result of mining.

The colliery owners representative was supportive of that view.

The Commission concurred but recommended no further leases, nor extension of leases should be granted by the Government without the concurrence of the Water Board.

Settlement On Catchment:
The President of the Water Board had stated that the proclaimed catchment was less than the actual catchment and that there were

715 human beings owning 4, 358 animals within the watershed, and intended asking for £30,000 to deal with the urgent cases and estimated the cost of resuming at £150,000.

Holders of alienated land within the Water Reserve "are in the habit of putting their cattle to graze on the Reserve. We consider that this practice should be absolutely stopped".

The Kangaloon Cemetery was also in the Water Reserve and further burials were recommended against.

It was recommended that: *"the entire catchment should be proclaimed and resumed."*

Cutting Timber On Catchment Area:
In general terms the cutting of any standing timber on the catchment was to be prohibited.

Summary of Recommendation - Report No 2:
In addition to the Recommendations in Report No 1 the following was recommended, and is summarised below:

a) Construction of a storage dam on the Cataract River to impound 7,000,000,000 gallons. Estimated cost £126,000, (ie for a medium sized dam).

b) That inquiry be held by the Water Board into the causes of the excessive waste of water

c) That the annual charge of 10 shillings on the use of a hose be abolished.

d) Improved methods of street watering (Newcastle had tried salt water).

e) No further mining leases without Water Board concurrence

f) No more cattle grazing.

g) Kangaloon Cemetery be closed to further interments.

h) Catchment area be proclaimed.

i) Cutting of timber to be prohibited.

5 members of the 8 member Commission signed the Report, including the President, Joseph Davis, who was Under-Secretary of Public Works.

An additional report was endorsed by Thomas Hughes, Lord Mayor of Sydney; Thomas Keele, Principal Engineer Harbours and Rivers; and L A B Wade, Principal Engineer Water Supply and Sewerage Construction. It recommended that provision be made for the dam to be raised in future to impound 18,200,000,000 gallons at a total capital cost of £217,000. For the present 7,000,000,000 gallons should be constructed for £186,000.

(Upsizing was thought to be necessary because of the limited Upper Nepean catchment size of 354 square miles).

3rd and Final Report: (Issued 10 October 1903)
4 witnesses were called

- Lewis Pritchard MOLINE..... Melbourne
- Arthur Francis JACOB..... Resident Engineer, Prospect Reservoir
- Arthur Lewingdon LLOYD ..... Chief Surveyor, Water Supply & Sewerage, Construction, Coast Branch PWD

Arthur Edward CUTLER..... Principal Assistant Engineer, Water Supply & Sewerage Construction PWD

On the recommendation of the Premier, the commission had been "strengthened" by the addition on 15 September 1902 of

Hon John Jacob GARRARD... President of the Water Board (and former Secretary for Public Works)
John Barrie JOHNSTON..... Chamber of Commerce
John Francis SMITH MP
John Plant WRIGHT..... Chamber of Manufacturers

and in addition

Joshua Percy JOSEPHSON... on 27 October 1902

The Commission had had 5 extensions. Happily Prospect Reservoir overflowed on 11 September 1903 and greatly relieved the situation.

The report noted that there had been 25% reduction per capita from 1901/02 to 1902/03. This had been achieved chiefly due to curtailment in the use of water for street sprinkling but also care exercised by the *"general public".*

The Joint Parliamentary Standing Committee on Public Works (JPSCPW) had recommended on 12 July 1902 (2nd report was 7 July 1902) for a single larger size dam ie 18,200 million gallons at a cost not exceeding £217,000.

The work had commenced in about October 1902. By the time of the 3rd Report, the excavations for the foundation were said to be nearly completed and the necessary plant was on the ground. It was expected to be completed by October 1905. However to avert water scarcity *"the water will be gradually allowed to accumulate while it is being built".*

Responsibility for the dam had been in the hands of the Water Supply an Sewerage Construction Branch of the PWD. This Branch was under L.A.B. Wade. Due to the urgency, the Harbours and Rivers Branch had been enlisted to help with the Project. Its head was Thomas Keele and both had been members of the *"minority group"* who had recommended that provision be made for Cataract to be built for future extension to the larger size. In 1902 the water situation was extremely serious. Wade and the Department Under-Secretary, Joseph Davis, were away from Sydney involved with River Murray issues. Thomas Keele prepared a design for a full size dam at Cataract only and presented it to the JPSCPW. He did this with the support of the Acting Under-Secretary, Joseph Hanna. The Parliamentary Committee approved and in turn the parliament approved of Keele's design and estimate. When it came to the 3rd Report of the Royal Commission, Joseph Hanna did not sign whereas all of the other twelve (12) commissioners, including Keele and Wade, did.

The necessary surveys had been made on the Cordeaux and Nepean Rivers. 27,000 million gallons could then be impounded at Cordeaux, Nepean and Chain of Ponds in three concrete dams.

To quote further from the 3rd Report:

"Reservoirs on the additional sites together with that now being constructed on the Cataract River and the existing Prospect Reservoir, would impound 50,000 million gallons of water, which would be sufficient for a year's supply without rain for a population of

two and a quarter million or four times the present population, consuming 60 gallons per head per day.

As other sites have been discovered on the Avon and Burke Rivers in addition to those above mentioned, on which large quantities of water can be stored, it is clear that the catchment area of the Sydney Water Supply, if the necessary prevision is exercised, and the rainfall conserved as required to meet increasing consumption is amply sufficient for many generations to come.

The people of Sydney are, we think to be congratulated when having so favourably situated and naturally formed sources for their water supply, and we are convinced that if our recommendations as to the strict preservation of the catchment area are acted upon, and the water thoroughly strained before admission to the service mains, its quality can always be maintained at a high standard of purity".

It also recommended some general works, such as re-construction of a part of the Lower Canal, be carried out.

2.4 Enquiries

2.4.1 Before Construction

In 1852 there had been an enquiry authorised by the Governor-General of NSW. It considered a Nepean River Scheme but instead had recommended a cheaper option, ie the Botany Swamps Water Supply Scheme which was completed in 1859. The scheme had water shortages as early as 1862; the water had to be shut off each night to conserve it.

In 1867 through to 1869 there was the Sydney Water Commission under the Presidency of Professor John Smith. After much controversy, it recommended in 1869 the fairly radical Upper Nepean Scheme. Due to controversy, little was done. In 1877, the Government asked a British Engineer, Mr. W. Clark, to review the 1867/69 Royal Commission. Mr. Clark supported the Upper Nepean Case. The Upper Nepean Scheme commenced in 1880 and was completed in 1888.

2.4.2 During Construction

The seeds had been sown for a number of controversies both personal and technical, between colleagues, former

colleagues, between Departments and Ministers and most definitely financial controversies.

These matters came to a head in the two Royal Commission of 1905. The Dam had been authorised by the Parliament for a certain height and a certain capacity. However the stated height did not coincide with that certain capacity. This was because a 300 acre valley had been missed on the original survey. The JPSCPW had recommended the submission by Mr. Keele ie a dam of 18,200,000,000 gallons at a cost of £217,000. The 3rd report from the Royal Commission had noted this and also that water would be allowed to accumulate during construction. (The Parliament in 1902 had passed an Act for a dam 160 feet (foundation level) ie 150 feet from river bed with a storage capacity of about 18,200 million gallons.)

The Secretary for Public Works from 1899 to 1904, was E.W. O'Sullivan. He had initiated the Central Railway Station and dealt with the plagues in inner Sydney. There was a change of Government in August 1904 and the new Secretary was Charles A. Lee, who had already been Secretary at an earlier time.

In 1905 the work which was to be let and completed by contract, was well underway, the contract time for completion being two years. It had been worked out more accurately that a 160 feet high dam (150 feet above river bed) would store 21,411 million gallons. The Secretary for Public Works, on the recommendation of L.A.B. Wade, directed a reduction by 5 feet (ie to store 18,600 million gallons) Mr Keele who had by then become President of the Water Board. The Board (advised by Mr Keele) urged the Secretary to build to the height stated in the construction Act. The decision was referred to a Royal Commission, the first of 1905.

Mr Stuart Murray - President	Chief Engineer, Water Supply, Victoria
Mr E M de Burgh	PWD, Principal Assistant Engineer for Rivers, Water Supply & Drainage
Mr C W Smith.....	Water Board, Superintending Engineer

The Royal Commission unanimously recommended the storage of 21,411 million gallons. This had to be done before the contract was let.

One can imagine that the Commission had little option. The foundations had been constructed to withstand the greater height. To have left off the top 5 feet would have been a waste of resources.

In the second Royal Commission of 1905, the issue of storing water during construction was an issue as it affected costs. Also having been built it did not completely fill with water until 1911, ie 4 years later. When it did fill in 1911 it was obvious that the spillway needed to be corrected because the flood waters eroded the left hand bank near the Lower Valve House. In addition to that, the valves were not operating satisfactorily. The spillway and the Lower Valve House were both extended in 1915.

3.0 CONSTRUCTION OF THE DAM

3.1 Dam Construction

At the time of construction Cataract was the "largest work of its kind in the Southern Hemisphere," and "work of a similar character and magnitude had not previously been carried out anywhere in Australia." This is recorded in the second Royal Commission of 1905.

3.1.1 Methods

Construction work started on the dam in 1902. The initial work was carried out by the NSW Department of Public Works. The early work consisted of excavating the foundations at the site but in addition clearing the timber over the area which was later to be inundated. It seems surprising that clearing of the timber was given such a high priority. However the timber which was cleared was then able to be used for the burning to generate steam and in turn generate electricity to commence the work. The 6 ton cableways were used to remove spoil from the excavations. Without the power generation this could not have been achieved so readily.

Power was generated by an on-site steam driven power station. Two stationary 16ft x 18ft tubular boilers (Spec 1905) powered 3 sets of direct coupled dynamos, each of 101 BHP, 300 rpm produced 500 volts 135 Amp (PWD 1904). There were in all 4 sets of self propelled steam cranes and eight boilers scattered around the Cataract Dam worksite (Spec 1905).

The construction started in late 1902 and was completed by the end of 1907. The initial work was by PWD day labour. The later work was carried out by contractors Lane & Peters. The estimated price for that contract was £147,412. The final project was transferred to the Water Board for a total cost of £329,136 (Aird).

Appendix C3, Figure 2 shows a typical cross section through the dam wall. Many people have imagined that Cataract and the other later Upper Nepean dams were constructed solely from concrete. However, the wall was constructed using cyclopean masonry composed of large sandstone blocks (plums) quarried at the site either at the spillway (on the western side) or from another nearby quarry near the

cableway Head Tower. Photograph No. 8 (taken at the later Cataract Museum) shows a *"dressed"* block. The blocks were about 4m long by 1m deep by 1m wide. Each block was bedded in cement mortar, and the vertical joints were filled with sandstone concrete. (Basalt concrete being used near the upstream or downstream face.) The upstream face consisted of basalt concrete moulded blocks set in cement mortar. These were manufactured on site. The downstream face is a basalt concrete 6ft thick in the lower part of the dam and 3ft thick at the upper levels. The original design, developed by Mr Keele, did not include the basalt facing which was added to by the PWD during detail design of the structure.

A detailed description of the concept of cyclopean masonry was written by L A B Wade, the Chief Engineer. That article is still relevant and was re-published as part of the 1984 Surveillance Report, (attached).

Sand was obtained locally by crushing the smaller pieces of sandstone. Basalt was obtained from a quarry at Sherbrooke 5 ½ miles away, hence the need for the 2ft gauge railway line.

Timing: The cableway was needed very early. The basalt was primarily required for the contract ie after April 1903. The railway was also used for firewood, in order to generate power particularly for the cableway.

Railway: (As part of construction)
Basically the railway ran from the dam wall RL 952 feet to Sherbrooke. (Final TWL was 950 feet.) In so doing it descended to a level of 880 feet as it crossed to the other side (Southern) of Cataract Creek.

There was a branch line to the Power House. The problem was to be that as the water level rose supplies of basalt were also cut-off and supplies of wood for the power house were to be cut off. The railway had not been proposed in the original planning. With the railway in place PWD were reluctant to allow the dam to fill progressively as enunciated by the 1903 Royal Commission 3rd Report.

Close to the dam site there was a branch to the sawmill, the basalt block moulding plant and possibly to the sandstone

APPENDIX A (CONTINUED)

CYCLOPEAN MASONRY

AT CATARACT DAM

(EXTRACTS FROM REF. 3) **LAB Wade**

"The body of the dam was constructed of cyclopean rubble masonry consisting of roughly rectangular blocks of sandstone weighing 2 to 4½ tons, built to break joint vertically and horizontally and to have a maximum of bond. The stones were bedded in cement mortar and the vertical joints were made with basalt and altered-sandstone concrete."

"The sandstone blocks forming the cyclopean rubble masonry were quarried from selected layers in the spillway quarry and a quarry at the opposite end of the wall. The face of the quarry was broken down by blasting in large masses; the stones were then cut from the selected layers by means of wedges and required a very small amount of additional work to meet the requirements of the specification. About 50 per cent of the sandstone material quarried was run to spoil as unsuitable for use in the wall.

The methods adopted in the construction of the body of the wall were the following. The hearting masonry was measured in its complete bulk, and no account was taken of the relative quantities of sandstone blocks, cement mortar and No. 3 concrete of which it was composed. The contractor was allowed to vary the relative quantities of stone, mortar and concrete, making up the hearing masonry by putting more or less than 70 percent of the total bulk of the hearting masonry. Should the contractor put in a less proportion of sandstone blocks than the 70 per cent specified, the engineers had power to value the additional cement used, and to deduct such value from any money due, or becoming due, in respect of the contract. It was found during construction, however, that the ratio 65 to 35, of sandstone blocks to concrete and mortar, represented better work in securing bond and packing than the 70 per cent of blocks specified, and the specification was deviated from to that extent.

The whole of the hearting between the upstream and downstream facework was composed of masonry built of sandstone blocks of as large a size as practicable, and hewn to a roughly rectangular form, no stone being less than 2 feet in depth, or with a less cubical capacity than 20 feet when measured on its smallest dimensions. The bulk of the stones were used green as they came from the quarry and were thoroughly wetted before laying. No horizontal courses were permitted. Vertical joints between adjacent stones, which were large enough and in such a position as to admit of concrete being thoroughly rammed therein, were filled with No. 3 concrete, all other joints being thoroughly

APPENDIX A (CONTINUED)

filled with cement mortar. In cases where it was necessary to make up a bed No. 3 concrete was used, or the contractor was allowed, with the approval of the superintending officer, to build in selected hand-stones, laid in cement mortar. The use of cement mortar in beds, joints or filling where No. 3 concrete or sandstone rubble could be used was not allowed, nor was the use allowed of sandstone blocks so roughly hewn as to cause the mortar and concrete used in the hearting masonry to exceed the specified proportions.

No difficulty was experienced in securing good bedding of the large blocks; a system of wriggling the stones on the mortar beds with bars expelled all air and gave much better results than ramming. Of the many stones lifted after being set, all were found to be free from air spaces in their beds."

block quarry at the dam site and the sand washing plant (which was near the sawmill).

3.1.2. Workers

The temporary town "Cataract City" provided for 500 workers and their families, this averaged 1,500 people. Single men were housed in barracks with 2 men per room. Married men built separate cottages for their families at their own expense. Shops, schools, reading rooms, recreation halls and churches were provided. Great care went in determining the suitability of the shopkeepers. Medical officers were also employed. The town at Cataract was on a water supply catchment. The Upper Nepean "run of the river" scheme having started operation back in 1886, (ie supplying the Hudson's Temporary Scheme). A sewerage pan scheme was installed. The alternative would have been to build the town further away from the worksite and in another catchment (the Georges River). However the 2 miles was thought to be too far. Workers were taxed a portion of their pay to cover the cost of providing the facilities. The fact that the Upper Nepean System had very little storage for detention added to the seriousness of pollution.

3.1.3 Machinery

The locomotive known as *"KATE"* had been purchased from Colonial Sugar Refineries, who had imported it but had not used it. (Question 9780 of 2nd 1905 Royal Commission).

Other Mobile Power: This was provided by man haulage, horse power and a variety of lifting devices from small steam cranes, electric powered stiff legged derricks to the main cableway. The *"Lidgerwood"* cableway (named after its New York manufacturing company) spanned 1,100 feet across the gorge. The western (Spillway end) towers were fixed in position whilst the northern end head towers traversed up-stream and downstream as requested. Empty skips were lowered into the excavated foundations, manually filled with spoil, then lifted out by cranes and pulled to tipping sites by horses.

Sherbrooke Quarry: a stationary steam engine powered the gyrating crushers and also ropeway. 60 tons of crushed basalt could be supplied by the crushers each day.

3.1.4 Changes

3.1.4.1 General

At future dams changes were made. Cataract had been one of the first major projects to use electricity. That electricity was generated on site by first producing steam by burning timber. In the case of Cordeaux Dam approximately 15 years later (which included the First World War) power lines were constructed from the Port Kembla Power Station.

The cableway was transferred to Burrinjuck, so very necessary at the start of a project for removal of spoil. The cableway is still at Burrinjuck and was used for the 1951 upgrading but not for the 1990 upgrading. The electric winch is branded Lidgerwood 1892. With Burrinjuck construction being over an extended time, 1907-1927 the cableway would have been unavailable for Balmain Reservoir construction in 1916. Hence the Balmain Cableway probably went to Cordeaux Dam and in turn to Avon, Nepean, Woronora and Warragamba (ie the smaller Warragamba cableway).

3.1.4.2 Other Dams

Cataract was the only dam which used the basalt concrete blocks on the upstream face. The later Upper Nepean Dams still used cyclopean masonry with basalt concrete on the upstream face and the downstream face.

Woronora Dam, 1935 used cyclopean masonry, in its bottom half but changed to full concrete for the top section for economic reasons. Although cyclopean masonry, Burrinjuck's cyclopean "plums", were the local red granite which was taken from the spillways. They are reported to have been much larger *"plums"* than those used at Cataract.

Dams are often sited below a river junction, which gives storage in 2 directions such as Cataract or as in the case of Avon and Woronora upstream of a junction with a deep spillway channel cut across to make use of the adjacent water course as a spillway.

3.2 Impact of the Dam

3.2.1 Wide Ranging Effects

The dam improved the security of the Sydney water supply. However initially it did not fully appear to do so. Although completed in 1907, it did not fill for the first time until 1911. This shows the controversy of building dams. Although it was started in a rush in 1902 full value for the money spent was not obviously achieved until the 1911 flood. That flood was too large for the spillway and caused erosion near the toe of the dam.

One effect on the Upper Nepean Scheme was that it was no longer a "run of the river" scheme and as a result compensation weirs had to be constructed in the agricultural areas of the Nepean Valley. The step had been foreshadowed by Mr Clark in 1877 who warned against releasing water for agricultural purposes. In the case of Cataract Dam, Menangle Weir had been built as an emergency temporary weir for the drought in 1902. It was a simple matter of re-designating Menangle Weir as a compensation weir. It is the oldest of the 9 compensation weirs and they are maintained by the Water Board.

Close examination of the Menangle Railway Bridge shows another effect. There are intermediate brick pylons at the mid points between the original stone pylons. This was to strengthen the bridge to allow for heavier locomotives which were coming into service. Before the intermediate pylons were built the Water Board was consulted and because of the holding capacity of the Upper Nepean Dams, it was felt that the flood height would be less and that the floodway beneath the bridge could withstand the obstruction of the intermediate pylons.

3.2.2 Development

The completion of Cataract in 1907 allowed Burrinjuck to commence in that year. Many of the personnel and much of the machinery moved onto Burrinjuck, including the Lidgerwood cableway.

With the dam being such a major structure, *"Official Quarters"* for visitors were constructed in 1910 on the site where the cableway head tower used to move along the rails on the flat ground. The title *"Official Quarters"* did not shield it because it was badly attacked by termites in the 1930's.

With a well known attraction the Cataract Scout Camp was set up on the dam entrance road on the former Wedderburn State Forest in 1984. This is outside the Cataract Catchment Area. The Camp obtains its water from the Dam, at off-peak times via the picnic area water supply and at other peak times (such as World and Australian Jamborees) by pumping direct from the lake with a temporarily erected large generator and pump.

3.2.3 Other Major Works

In the 1920's the Water Board built a 10 foot diameter Pressure Tunnel from Potts Hill (Bankstown) to the City, a distance of 10 miles. The tunnel ruptured and a Royal Commission was held in 1933. The repairs to the tunnel resulted in a tunnel of only 8 foot, 3 inches diameter despite the additional expenditure of over £1 million at the height of the Great Depression. A scheme was proposed to make up for this reduced capacity, building a series of tunnels and pipelines from Cataract Dam to Potts Hill. These are shown in Appendix "A7" which is a copy from the 1933 Royal Commission Report. The proposer of this scheme was Gerald Haskins, then Chief Engineer of the Water Board and previously Deputy Chief Engineer at Hume Weir. He later founded the leading consulting firm Gutteridge, Haskins and Davey. The same brand of valve, Larner-Johnson, has been used at Cataract Dam, Hume Weir and the Pressure Tunnel. Hume Weir was the last major dam for E.M. Burgh who retired in 1927 and died in 1929.

One of the many deficiencies in the construction of the Pressure Tunnel had been the use of sandstone concrete as a water retaining structure. In the remedial work at the Pressure Tunnel, bluestone (basalt) concrete was used. In the case of Cataract Dam it had originally been proposed by T W Keele to be built solely from sandstone concrete, with small sandstone plums, but was later changed to have basalt concrete blocks on the upstream face and basalt concrete on the downstream face. This was to improve its lasting characteristics and also its watertightness.

The Pressure Tunnel construction had not learned from the New York Tunnel rupture of 1906 re the Great Catskills Water Supply Scheme nor had they appreciated the significance of the bluestone concrete at Cataract as

discussed in 1905 Cataract Royal Commission. (Ref. Appendix A7.)

The name of Thomas Keele is mentioned in the 1933 Royal Commission, even though he had died in 1927 having, in retirement, been elected as a member of the Appointed Board of the Water Board from 1923 to 1927.

4.0 OPERATIONS OF THE DAM

4.1 Droughts

It was the extreme drought of 1902 which led to Cataract Dam being commenced. At that stage Prospect Reservoir was the only substantial storage within the Upper Nepean Scheme. Prospect had fallen below 6 metres (20 feet) and consequently water would not gravitate out of Prospect (see notice authorised by the Secretary of the Board Mr W C Holmes). During 1903 it rained heavily and Prospect re-filled. This removed some of the urgency from the Cataract Dam question. The Upper Nepean Scheme was basically a "run of the river system" (At a much later time in the 1940's Warragamba began as a "run of the river" system until such time as the major dam started to hold water during its construction in the 1950's.

Cataract Dam became capable of storing water from 1905. However it was only used for supply when the "run of the river" from the other 3 rivers became insufficient.

4.2 Floods

When Cataract was completed in 1907 it then took another 4 years before it filled for the fist time. At that first filling it was realised that the training wall would need to be raised and lengthened. The floodwaters were scouring at the toe of the main wall near the Lower Valve House on the western side. This work, along with extending the Lower House downstream by 15m, was completed in 1915. The Valve House extensions were required because of difficulty with operating the 2 outlets, (Ref. Appendix C4).

In 1898, prior to the building of Cataract, a flood had destroyed Broughton's Pass Weir. Supply was continued by building a temporary aqueduct from Nepean Tunnel to Cataract Tunnel, by-passing Cataract River water. This principle was re-activated during Cataract construction because of the urban run-off pollution from Cataract City.

4.3 Bushfires

Bushfires are a particular problem for water quality. Firstly the carbon washing into the water allows the disinfecting agent chlorine to combine with it and in turn reduce the disinfection. In 1965 the Upper Valve House and the timber stop boards were completely burnt out. The historic roof was re-built. The heat distorted some of

the stone work in the building. As from about 1980 it had been possible to drive across the dam and along the western fire road. That new road helps with the control of bushfires and catchment management.

4.4 War

4.4.1 World War 1

W.C. Holmes, the Water Board's second Secretary issued the water restriction document re Prospect Reservoir in 1902. He was also present in 1908 at the official transfer of the Dam to the Water Board. By 1915 he was a Major General commanding the 5th Division at Gallipolli and later in France. He was killed in action at Trois Arbres and was the highest ranking Australian soldier killed in WW1 (he was escorting the then Premier of NSW on an inspection). He was level ranking with Major General Sir John Monash who in 1918 became the leader of all Allied forces. Both Monash and Holmes had been members of the part time Army. Monash being a successful Civil Engineer and Holmes being Secretary to a then major Engineering organisation. There is a plaque honouring Major General Holmes in the foyer of the Board's Head Office in Sydney.

When Balmain Reservoir was opened in 1918 a plaque was erected to Major General Holmes. That plaque has since been moved to the major roadway General Holmes Drive near Sydney's Kingsford-Smith Airport. The Airport site was near Sydney's early water supply before Upper Nepean (ie Botany Swamps) and later the Botany Sewage Farm from 1889.

4.4.2 World War 2

The Dam Buster raids took place in Germany in 1942, (refer Appendix B2; Mohne, Eder & Sorpe Dams). It involved the dropping of a "skipping" torpedo as described in the book and film of the same name. It was possible that the same type of device could have been used against Australian dams. Whilst there is no official record it appears that staff at Cataract Dam set up a floating cable device to deflect such devices. The protective equipment involved long sapling trees with a hole bored through each end, presumably for a cable and the attachment of 300mm diameter circular floats about 1.5m long.

It had been suggested that these devices may have been log protectors to keep timber away from the dam wall. However the floats do appear to have been painted black presumably for camouflage reasons. Photographs are attached as Photograph No. 7, (they are normally under water).

Strategically Cataract is more important since discharge from the other 3 dams has to flow through the 7km Nepean Tunnel before entering Cataract Tunnel and then the Upper Canal. Any damage to the Nepean Tunnel would increase the importance of Cataract Dam.

4.5 UPGRADES

4.5.1 General

The dam was completed in 1907. It was capable of supply before that time, the same as for most dams (Burrinjuck, Warragamba etc). The outlet valves were a problem from the beginning. The valves were not fully tested until the dam first filled in the flood of 1911. That flood proved the need to extend the spillway further downstream and build and extend the spillway training wall and the Lower Valve House. The major works were carried out by 1915.

4.5.2 Spillway

The spillway was extended downstream by excavation. In addition the spillway training wall was extended downstream.

In about 1980, after research about larger possible floods the spillway crest was strengthened by the insertion of solid vertical steel anchors (passive) in the rock below. The training wall itself was re-built to a greater height and secured by solid steel vertical anchors which were post-tensioned after construction. The tension on these anchors is checked every year. The process involves minute jacking of the caps to ensure they are still in tension. One jack is used and is moved along. (This is similar to the process used in checking the cable tensions at the Sydney Harbour Bridge during the 1920's and 30's), (NEL Feb. 1988).

4.5.3 Main Wall

The main wall has been stabilised by the insertion of vertical steel cables which were post-tensioned after insertion in the late 1980's. The tension on these cables is also checked annually with a special hydraulic jack. As well as the vertical tension cables there are also horizontal rods near the top of the dam which run at right-angles to the main wall. These also required tensioning. The vertical cables are shown in Appendix C5. The vertical cables had to be located to avoid the 4 off 1200mm via outlets. The cables have a differing number of strands, depending on their function.

Sophisticated electronic measuring equipment was installed before the stressing began.

4.5.4 Outlets

The dam has/had 4 outlet pipes, 2 of these are/were for normal supply, ie the inner 2 whilst the outer 2 were either for construction diversion or for emergency dewatering of the dam. All 4 outlets were fitted with cast iron black flanges in line with the upstream face of the dam. After 80 years it was realised that the cast iron may have graphitised and therefore mass concrete placed in tremi style (ie underwater) was supervised by divers upstream of the four blank flanges. Before placement of concrete the silt had to be removed from the floor by an underwater "vacuum cleaner", (Ref. Snape, D.W. and Dowd, R.W.).

4.5.4.1 Inner Outlets

Supply to the two inner outlets was provided through one of four penstocks so that water could be taken from a particular level at the dam (see Appendix C4). There were 4 levels to chose from with only one of the 4 penstock to be opened. The one being opened was determined on a water quality basis. If either Penstock 1 or Penstock 2 was opened, then only Eastern Outlet could be used. Conversely Penstock 3 or 4 could only supply via the Western Outlet.

In droughts if the water level ever fell below Penstocks 3 and 4 then only the Eastern Outlet could continue to be used to supply water coming

through Penstock 1 or Penstock 2. For that reason Eastern Outlet was and still is technically the primary outlet if water levels fell severely. Since completion of the other Upper Nepean Dams this is not a major concern.

For the first 70 years supply water went through coarse screens which ran all the ways from top to bottom. In the case of the Eastern Outlet they covered Penstock No 1 and No 2, whereas the screens for the Western Outlet were relevant for Penstock No 3 and No 4. In the late 1970's the coarse screens were abandoned and in their place were put finer screens inserted with stop boards so that water is now drawn off only from a narrow band. This process has improved water quality. All of the other 3 Upper Nepean Dams plus Warragamba were fitted with this option as part of their original construction.

4.5.4.2 Outer Outlets

The outer outlets were considered for emergency dewatering. This would have required removal of the upstream blank flanges by divers. With the operation being controlled by the gate valves. Although it would have been possible to open them, assisted by water pressure, it would have been near impossible to close them until the water had run out. Needle valves, butterfly valves or sleeve valves are used for stopping and starting and varying flows. The gate valves only provided "guarding" action.

4.5.4.3 Emergency Situations

If the needle valves on the inner outlets had ever "locked open" it would have been difficult to stem the flow. The possible options were:

1. Stop boards
2. Penstocks
3. Guard Valves (ie stop valve)

none of these options are designed to reduce large flows. (A runaway condition occurred at Burrinjuck in 1974).

Two emergency *"ring follower"* valves have now been installed at Cataract. They can be operated by remote control from the Upper Valve House. In the event of power failure these valves can be operated by hand from the roof of the Lower Valve House. The Lower Valve House itself is inaccessible during large floods, (see Appendix C6).

4.6 Communications & Power

4.6.1 Communications

Initially there was no Telecom (previously PMG) service. Therefore the Water Board built its own internal service basically running the phone wires alongside the water canal to the Bulkwater Branch Headquarters at Guildford. At a later time Telecom services became available and both services were used for many years, along with a radio phone system since the 1950's.

4.6.2 Electrical Power

Initially there was no electric power after the construction finished. County Council power was provided in the 1930's. In order to provide power for the large drilling works in the late 1970's the power was upgraded from Appin, along the route of the old access road. This supply was of benefit to the Scout Association when they established the Scout Jamboree site in the early 1980's.

4.6.3 Wider Communications

The Sydney-Melbourne co-axial cable crosses underneath the Nepean river just upstream of Pheasant's Nest Weir.

4.7 Dam Safety

4.7.1 General

Regular inspections of the dam have been carried out by the local staff. This is under the control of Professional

Engineers who in turn analyse results and carried out very detailed regular inspections. (Early detailed reports refer to the NSW Dam Committee with reports being signed by the Board's Engineers-in-Chief.)

4.7.2 Recent

In the 1977 the NSW Dam Safety Act was passed and it set up the NSW Dam Safety Committee. The necessity to upgrade for floods greater than originally allowed for was a major issue. Also the matter of coal mining, particularly long wall mining has been a major issue for Cataract Dam. Both these issues have been extensively covered in the Dam Surveillance Reports of 1984 and 1989. Coal mining was also mentioned in the 1902 Royal Commission.

4.7.3 Galleries

There is only one short gallery at Cataract Dam. It led off easterly from the Lower Valve House and is to allow for the local water supply. As part of the upgrading work consideration was given to excavating (or mining) galleries into the existing dam but this was not considered necessary in view of the post tensioning methods used. (The 1951 upgrading of Burrinjuck Dam used this method to reduce "uplift". Post tensioned cables were not used at Burrinjuck until the 1990's, (ref. Munday, S M).

4.8 Residents and Visitors

4.8.1 Visitors

Cataract Dam being such a large structure has had many visitors. The Official Quarters, built in 1910 has housed them. Historic photograph No 19 shows then Governor General Lord Munro Ferguson on a visit to Cataract in 1916. In 1985 the then Governor General Sir Ninian Stephen stayed and at another time so did the King of Sweden.

4.8.2 Residents

Over the years, about 5 permanent staff members lived on the site, often with their families in the picturesque cottages, 3 of which are stone.

4.9 Transport

The nearest town is the village of Appin. This is approximately 5 km from the dam site. The old direct road has been effectively replaced by the Bulli-Appin Road. This dam brought great wealth to Appin during construction. It also brought business to Campbelltown on the Main Southern Railway Line. Campbelltown itself had benefited from the Upper Nepean Scheme being the first non-river town in NSW to receive a water supply in 1888. It was the rail head for heavy equipment for Cataract.

The road from Campbelltown passes the monument to where Hume and Hovell set out on their southern exploration in 1824. E M de Burgh later became Chief Engineer for Hume Weir on the River Murray and the Deputy Resident Engineer was Gerald Haskins who later became Chief Engineer of the Sydney Water Board. Haskins was responsible for the remedial works on the Pressure Tunnel (refer Appendix C4) and later founded Gutteridge, Haskins and Davey.

Stuart Murray, who had been President of the first 1905 Cataract Royal Commission, had been instigator for the Victoria section of the River Murray Works. de Burgh was a member of that Royal Commission.

5 COMPARISON WITH OTHER DAMS

5.1 General

A register of dams is maintained by the International Commission on Large Dams (ICOLD). Dams within Australia are listed under the Australian National Committee on Large Dams (ANCOLD). At the second Royal Commission of 1905, Cataract is described as "the largest work of its kind in the Southern Hemisphere". The ICOLD Register does not appear to totally support this statement. The term largest could be defined in different ways; is it the highest? The greatest capacity? The greatest active capacity? The largest catchment? etc.

5.2 Within Australia

The Mundaring Weir in Western Australia is shown as having a capacity of 76,390,000 cubic metres with a height of 71m above the lowest foundation. These figures are for 1973. However Mundaring was raised by 9.8m in 1951. therefore its height in 1902 would have been 61.2m. The corresponding height of Cataract 59m has remained changed and its capacity is 94,300,000 cubic metres. Therefore Cataract certainly had the largest capacity but was not the highest (unless Mundaring was raised more than once). Mundaring provided storage for the Coolgardie Goldfields Water Supply Scheme (NEL September 1987).

The most significant dam before that was Yan Yean, which was constructed in 1857 for the Melbourne Water Supply. It is a water supply dam built with a 12m earth fill wall. Its capacity was 1/3 of Cataract.

The first significant concrete gravity dam in Australia appears to have been the 15m Goulburn Weir on the Goulburn River in Victoria and was completed in 1890. Its capacity was also about 1/3 of Cataract and was for irrigation. Victoria was getting well ahead of NSW in irrigation terms under its Chief Engineer Stuart Murray. It was to be less affected by the drought of 1895/1902.

With the exception of the height of Mundaring Weir, Cataract was the largest storage dam in Australia. It was approximately twice that of Prospect Reservoir.

Burrinjuck, which followed Cataract, was higher than Cataract but initially had less capacity. It commenced in 1907, was operational by 1912, completed 1927, raised with gates 1951, further raising with post tensioning 1994. Burrinjuck had gates installed at the

TABLE

DAMS LARGER THAN CATARACT
based on ICOLD Listing 1973

Name	Type t	Country/ Location	Comple-tion Date	Ht. Above Found-ation m	Gross Capacity 10^3 cu. m	Purpose	ICOLD Folio
Cataract	PG	Syd. Aust	1907	59	94,300	S	2
Upamayo	PG	Peru	<1875	10	300,000	I	1
Mundaring	PG	WA, Aust	1902	*61.2	**76,390	S	2
Pokegama	PG	USA	1889	⊗	149,000	CNR	4
New Croton	PG	USA	1905	91	90,000	S	18
Post Falls	PG	USA	1906	23	781,000	H	20
Wachusett	PG	USA	1906	63	254,000	s	20

t PG gravity dam

tt S water supply

I irrigation

C flood control

N navigation (Mississippi River)

R recreation

* Listed as 71m but was raised by 9.8 m in 1951 (Journal IE Aust. Dec. 1953. D C Munro and H E Hunt, Nov. 1948. V C Munt).

** Listed as for 1973

⊗ Not recorded

same era as Warragamba and Mundaring Weir. Warragamba's post tensioning was done just before Burrinjuck's post tensioning.

5.3 Within the Southern Hemisphere

South Africa's 15m high Van Wyksvlei Dam (Appendix B3) was an earth fill dam completed in 1884. Its capacity was 157,000,000 cubic metres with a huge shallow lake of 50,000 square metres. Cataract's lake size is 8,510 ie approximately one fifth. Van Wyksvlei is an irrigation dam. It was not even reported in the 1973 ICOLD register, but is shown in 1988.

Upamayo Dam on the Lago Junin River in Peru (Appendix B2) is a concrete gravity dam built prior to 1875, 10m high and 83m wide with a capacity of 300,000,000 cubic metres capacity.

Technically Cataract was not the highest dam in the Southern Hemisphere, but it was the largest capacity non-irrigation dam.

5.4 World Ranking

At the time of completion in 1907 there were only 17 dams recorded on the ICOLD listing (Appendices B2 & B3), as having a storage greater than that of Cataract. There were the above two irrigation dams, ie the 15m earth dam in South Africa and the 10m gravity dam in Peru, plus fifteen dams in the U.S.A. Of these fifteen dams only three were gravity dams (see Table) ie Wachusett, the Boston Water Supply, which was 4m higher and Pokegama (height not recorded) on the Mississippi River and Post Falls (height 23m).

The records show that in terms of height of a gravity dam, Cataract ranked below New Croton, completed 1905 (slightly lesser storage); Wachusett, completed 1906; Mundaring Weir - W.A., completed 1902 and possibly Pokegama, whose height is not listed. However, with Pokegama being a flood control/navigation dam on the Mississippi River, it can be said that Cataract was the fourth highest gravity water supply dam in the world at that time. The above also shows that Mundaring Weir in Western Australia may have been the highest between 1902 and 1905 depending upon the height of Pokegama Dam.

On his trip in 1902/03, L A B Wade visited New Croton Dam (for the New City Water Supply), Wachusett for the Boston Water Supply and Spier Falls, near Glen Falls, 45.7m gravity, a hydro dam on the

Hudson River, completed 1905. C W Darley had visited New York and San Francisco and this is brought out in evidence.

6 THE PEOPLE

Edwin Orpen ***Moriarty*** - Engineer-in-Chief for Harbours & Rivers PWD. Instigated the Upper Nepean Scheme.

Cecil William ***Darley*** - Succeeded Moriarty in 1889 and became President (part-time)of the Water Board from 1892 to 1896. He was then promoted as Engineer-in-Chief of the PWD. Brother of Chief Justice and Lieutenant Governor of NSW, Sir Frederick Darley. (Sir Frederick Darley approved extensions of time for the 2nd 1905 Royal Commission.)

Leslie Augustus Burton ***Wade*** - Chief Engineer for PWD for the construction of Cataract Dam. Later became Chief Commissioner of the Water Conservation and Irrigation Commission (WC & IC). Travelled overseas to the USA in 1902 to study dam building techniques and for discussions with C W Darley who had recently retired to London as a consulting Engineer. His brother G C Wade, the Attorney-General and Member for Gordon, became Premier of NSW in 1909. (The Wade brothers' father was an Engineer, as was G C Wade's father-in-law).

Ernest Macartney ***de Burgh*** - Supervising Engineer for PWD for Cataract Dam and later for Burrinjuck Dam, (The small reservoir at Burrinjuck is Lake de Burgh). He was born in Ireland. He put forward proposals for the construction at Warragamba Dam in both 1908 and 1918. His other dams were to include Cordeaux Avon, Chichester and Hume Weir. He retired in 1927 and died in 1929.

de Burgh's son, Thomas, became an Engineer in 1912 and joined the PWD. He transferred to the Water Board in 1924. He became District Engineer Northern. He once had the job of re-building the watermain at de Burgh's Bridge which had been named after his father. On his retirement in 1954 he was elected as a member of the Appointed Board and was still in that role at the opening of Warragamba Dam in 1960.

Thomas William ***Keele*** - Principal Engineer Harbours and Rivers at PWD. Had surveyed the Nepean Tunnel prior to 1888. Became President (full-time) of the Water Board from 1904-1908. He appeared before the 1905 Royal Commission but was exonerated. However his term was not renewed in 1908 and he was effectively downgraded to the Sydney Harbour Trust. In 1917 he was a member of the Committee of Experts which recommended Cordeaux Dam. He later became an elected member of the Appointed Board. He was a member of the South Australian Royal Commission in 1902 to determine an outer harbour for Port Adelaide.

Lane and Peters - Won the contract to build Burrinjuck Dam.

John Job Crew ***Bradfield*** - Designed both Cataract Dam and Burrinjuck Dam. Career turned towards transport from 1905. He was responsible for the City Railway and the Sydney Harbour Bridge.

Harold Harvey ***Dare*** - Worked with Bradfield and Wade at PWD. Succeeded Wade as chief at WC1C in 1919. Provided specialist advice for testing of the Water Board's suspect Pressure Tunnel in 1929.

Arthur Edward ***Cutler*** - Principal Assistant Engineer at PWD. Later he became President of the Hunter District Water Board.

William Cedric ***Holmes*** - Secretary of the Water Board. Issued the restrictions re Prospect Reservoir in 1902. Was at Cataract for the handing over ceremony in 1908. Became a Major General in World War 1. Served at Gallipolli and France alongside Sir John Monash. Was killed in France in 1917. He was the highest ranking Australian killed. Buried at Trois Arbres.

Edward William ***O'Sullivan*** - Secretary for Public Works 1899 to 1904. Authorised the start of Cataract Dam and many other projects. Very involved with action re the plague in Sydney in the early 1900's championed the building of Central Railway Station. Was the member for Queanbeyan before it excluded the Australian Capital Territory. Was Secretary of Works for Pyrmont Bridge (NEL, June 1992).

Charles Alfred ***Lee*** - Became Secretary for Public Works when the Carruthers Government won the Elections in August 1904. Had been Secretary of Public Works prior to O'Sullivan. Instituted the two 1905 Royal Commissions. Was present at 1908 hand over of Cataract Dam. Was Secretary at the opening of Central Railway served with Attorney General G C Wade who became Premier in 1909 after Premier Carruthers' ill health.

7. CONTROVERSIES

There were many problems initiating the Upper Nepean Scheme and this continued in earnest with Cataract Dam.

7.1 1902 Royal Commission

The 2nd Report of this Royal Commission recommended a dam at Cataract of approximately 1/3 of the capacity to which Cataract was eventually built, and also that surveys were to be made of various dam sites.

Responsibility for the Cataract Project had been in the hands of L.A.B. Wade, a member of the *"group of three"*, see page 11. Thomas Keele, another member, and his Branch had only been involved with Cataract due to the urgency of the situation. Whilst Wade was away from Sydney on River Murray work, Keele did his own design and estimate for a full sized dam and presented it to the JPSCPW. The full parliament in turn approved construction of the Cataract Dam in September 1902. Work commenced almost immediately. In fact the PWD had arranged for purchase of a twin 6 tonne cableways even before the Act was passed. This was done by C. W. Darley, the then recently retired. Engineer-in-Chief of PWD. He had semi-retired in 1901 to London and became Inspecting Engineer for NSW Darley had been a foundation Board Member (1888), and the 2nd President of the Water Board from 1892 to 1896. In 1902, as part of his new role in London, he had been requested to investigate suitable machinery for Cataract. L.A.B. Wade, who was sent to the U.S.A. to learn more about dams, met up with his former chief in San Francisco.

7.2 First 1905 Royal Commission

This first commission was to determine the final height of the dam. The Parliament has approved a dam of a certain height and a certain capacity as put forward by Mr. Keele. However, there had been a survey mistake and a valley of 300 acres (125 hectares) had been *"missed"*. This only came to light when paying axemen for the amount of clearing. The capacity was thereby greater than expected. L.A.B. Wade chose to reduce the height of the dam by 5 feet (1.5m) and consequently excavated the spillway channel 5 feet deeper. Mr. Keele and the Water Board opposed the reduction in height. The Royal Commission unanimously supported the extra height. With this finalised, the contract was then able to be let, (to Lane and Peters).

7.3 Second 1905 Royal Commission

This Commission (linked with the first) was to determine the reason for over-expenditure on the Project and who was responsible for causing this over-expenditure, ie over the proposed expenditure as put forward initially to the JPSCPW.

In paragraph five of the 1905 Royal Commission, the cost has increased from £217,500 ($435,000) to an expected £350,000, ($400,000) ie an increase in excess of £132,000 ($264,000). (The £350,000 ($700,000 was for a 145 foot (44 metre) high dam, as against the original 150 foot (46 metre) high dam above river bed.)

For this the Secretary, C.A. Lee, considers that Thomas Keele has *"misled not only the Committee (JPSCPW), but the Parliament of the country" (paragraph five).*

In defending himself, Keele severely criticised his former colleagues, Wade and de Burgh who were, at that time, constructing the dam. Keele was exonerated but was effectively demoted. The final estimated cost was £325,496 ($650,992) for a 150 foot (46m) high dam.

Keele had proposed and costed a dam with no large cyclopean masonry. He considered they would promote cracking and they required skilled masons to prepare. Instead, he had proposed smaller stones which could be dug out randomly and carried by two unskilled men. This would have meant that the cableways would not have been required. Keele was concerned that the big blocks would get air bubbles underneath. Wade countered that the blocks were *"rocked"* with iron bars to reduce this, and some were removed whilst wet to check this. (The even large blocks at Burrinjuck did have some problems with this, they would have been harder to rock.), (ref. Munday, S.M.).

Keele had proposed that the dam be solely built from sandstone concrete, with small sandstone plums. The upstream face was to be of concrete richer in cement and the faces were to be coated with pure cement after the formwork was removed. This would have meant that the railway line would not have been necessary to obtain basalt and would probably not have been justified for firewood alone. However, Keele had to admit in evidence that if he had discovered basalt within 5½ miles (9 kilometres)of the construction site, he also would have used it for upstream and downstream facing as it provides a better quality job.

Keele criticised the use of the moulded basalt blocks on the upstream face. Wade claimed that they were preferable to try and prevent cracks. Keele was supported on this point and all future dams did not use the moulded blocks. (Wade would have been very concerned about cracks because it was a straight dam. Curved dams tend to close up the cracks when storing water - Burrinjuck, all Upper Nepean Dams and Worona were gravity dams but also curved.)

Keele criticised the way in which the foundations had been excavated. He felt that there should have been a trench put down to good foundation and then to quarry both sides of that trench. Wade had done it excavating virtually layer by layer to get a *"feel"* for the rock strata. The method was slower and more costly and the foundation went down 20 feet (6 metres) deeper than anticipated.

Wade wanted to make sure that the rock strata beds were not sloping downstream as this could have aided sliding downstream (paragraph 286). The 20 feet (6 metres) represented not only extra excavation but also extra construction material at the widest part of the dam because of the continuation of the downstream slope.

Keele had approval for a concrete dam. He criticised Wade's method of using large sandstone "plums" saying that it was a masonry dam. However, he did agree that even the small plums (or displacers) he proposed, made his method technically not a concrete dam either. The Royal Commissioner accepted Wade's explanation, a copy of which was re-produced in the 1984 Surveillance Report.

The dam which Keele had designed allowed for its western end to be part of the spillway. With the dam doubling as a partial spillway, the separate spillway could have been smaller and therefore less expensive. However, Wade argued that it would be unwise to have water flowing over such a high dam, because it could erode the toe of the dam. The Commissioner supported Wade. History in turn supported Wade further when, during the first flood after completion ie in 1911, water from the separate spillway did erode the toe of the dam. As a result the spillway was extended downstream by 1915.

Keele felt the job was over-loaded with machinery particularly cranes. Wade felt this number was justified through his American experience of using short jibbed cranes for transferring loads from one crane to another, whereas British tradition was for long jibs and fewer cranes. Wade instanced his 1903 visit to large dams in the

U.S.A. Wachusett, Glen Falls and Croton. He also quoted from a paper about the Vyrnwy Dam in India.

Wade had requested the Inspecting Engineer, C.W. Darley, to organise for 2 cableways and a set of concrete mixers in July 1902 ie 3 months before the Act of Parliament. (S243)

Darley visited America and went to a large dam being built on the Hudson River at Glen Falls for the Hudson River Power Co., the Croton Dam for the New York Water Supply Department and the Wachusett Dam for the Boston Water Supply. Keele favoured few cranes and a simple cableway as at the Barossa Dam in South Australia.

Electricity versus steam was discussed. Electricity has the advantage that it can also provide light for night shift work. (The lights were hung off the crane jibs.) Darley had written that Wachusett used compressed air, Hudson & Croton used steam. The Hudson Dam was switching to electricity even though half finished. Darley was the one who selected electricity.

Storage of Water During Construction. The railway line was in a location such that it would be submerged. The Royal Commission of 1902, 3rd Report, had noted that water was to be accumulated.

The Water Board had requested storage of 100 feet (30 metres) of water. This, however, meant that the parts of the railway would be flooded, along with the concrete mixer at the moulding yard. If the railway was flooded there would be no basalt and firewood could not be taken to the power house. The options were to speed up the job and possibly stockpile firewood. The railway did run 2 shifts, and if necessary the railway could have been re-built or the firewood could have been transported by boat.

Siting of the Camp. The camp should really have been built on the Georges River Catchment. There was a regular pan service and garbage collection service. The solution was that water from the Cataract River in low flow times was to be directed to pass over Broughton's Pass Weir (similar to when the Weir collapsed in 1898 under flood). The township drained to below the dam wall and otherwise would have gone directly into supply. The 1902 Royal Commission had demanded action re water quality. The Water Board's Medical Officer had reluctantly agreed to the camp site location.

After commencing this Royal Commission, the contract was let so that this partly avoided controversy as to the final cost; which was now a known factor. The Commission had to delay slightly the taking of evidence, as the evidence given may have advantaged certain contractors. It was argued that contractors charge more for excavation to improve their *"cash flow"* on a project.

8.0 BIBLIOGRAPHY:

AIRD, W.V. *"The Water Supply, Sewerage and Drainage of Sydney".* Halstead Press Pty Ltd. Kingsgrove NSW, 1961.

BEASLEY, M. *"The Sweat of Their Brows".* Published by the Water Board, Sydney, 1988

BORCHARDT, D.H. *"Checklist of Royal Commissions, Select Committees of Parliament and Boards of Enquiry. Part IV NSW 1855-1960."* Published by Bundoora, La Trobe University. 1975.

BUTLER, AUDREY Dictionary of Dates. 7th Edition. Published by M. M. Dent and Sons. 1986.

DARLEY, C.W. Paper *"Curved Concrete Walls for Storage Reservoirs",* read before the Royal Society of NSW. December 19, 1900.

de BURGH, E.M. *"The Practical Work of Starting a Great Engineering Enterprise".* Coltheart, L. and Fraser, D.J. editors. 1987. Landmarks in Public Works, Engineers and Their Works in NSW 1884-1914. Hale & Ironmonger, Sydney.

deBURGH, E.M. Report on Augmentation, Extension of Storages, Sydney Water Supply Catchment Area, the Warragamba and Other Schemes. 1918.

FARNSWORTH, S.T. Paper *"The Stability and Drainage of Cyclopean Masonry Dams"* - The Commonwealth Engineer, August 1931.

HENRY, F.J.J. *"The Water Supply and Sewerage of Sydney".* Published by the Water Board, 1939.

KEELE, T.W. Paper *"The Water Supply of Sydney, Past Present and Future"* read before the Royal Society. May 1908.

KEELE, T.W. Paper *"The Sydney Water Supply"* read before the Royal Society of NSW, July 1917. Vol. L1 pp.209-231.

KEELE, T.W. Report on Disposal of Waste Water from Cataract and Nepean Rivers for Irrigation Purposes. October 1905.

LONGWORTH, J. *"Dam Builders at the Close of Steam - Sydney's Cataract and Cordeaux Dam, 2 Foot Gauge Construction Tramways".* 1st Edition June 1990. Paper presented to the NSW Division of the LRRSA.

MBWS&S Official Handbook on Sydney Water Supply and Sewerage, 1913.

MWS&DB Cataract Dam Surveillance Report 1984 (for the NSW Dam Safety Committee).

MUNDAY, S.M *"Burrinjuck Dam - Strengthening and Enlargement".* Journal IE Aust. Vol. 27, No. 6, June 1955.

MUNRO, D.C. & HUND, H.E. *"The Raising of Mundaring Weir, Western Australia".* Journal IE Aust. Dec. 1953.

MUNT, V.C. *"The Raising of Mundaring Weir, Western Australia".* Journal IE Aust. Nov. 1948.

NAIRN & SEARLE *"Australian Dictionary of Biography".* E.M. de Burgh - J.J.C. Bradfield.

NEW SOUTH WALES 1852. Report from the Board. *"Supply of Pure Water to the City of Sydney"* Presented to the Legislative Council on 19th August 1852.

NEW SOUTH WALES 1876-7. Report to the Government of NSW on Various Projects for Supplying Sydney with Water. By Mr. W. Clark. 16 May 1877.

NEW SOUTH WALES 1884-87. Royal Commission on the Conservation of Water.

NEW SOUTH WALES 1902 Royal Commission on *"Sydney Water Supply".* 3 Reports.

NEW SOUTH WALES 1905 (1st) Royal Commission [on] Sydney Water Supply (Cataract Dam) (Height of Dam).

NEW SOUTH WALES 1905 (2nd) Royal Commission of Inquiry into the discrepancy between the estimated cost of the dam and the amount it is now anticipated it will cost to complete the structure.

NEW SOUTH WALES 1933. Royal Commission into certain matters under the Administrative Control of the MWS&DB (Pressure Tunnels).

NEW SOUTH WALES 1967/69. Report of the Commission appointed to Inquire into the Supply of Water to Sydney and its Suburbs.

NEW SOUTH WALES 1994. Joint Parliamentary Select Committee into the Water Board.

NEWLAND, J.R. *"The Goondah-Burrinjuck Railway"* ARHS Bulletin No. 596, June 122-142.

PWD 0F NSW Commemorative Volume. River Murray Waters Act - Home Reservoir. 1928.

PWD OF NSW *"The History of Public Works in NSW".* Ed. L. Coltheart and D.J. Fraser, 1988.

RAXWORTHY, RICHARD, *"The Unreasonable man, The Life and Work of J.J.C. Bradfield".* 1989. Hale & Ironmonger.

ROSEBY, T.J. Commemorative Volume. Sydney Water Supply and Sewerage (Water Board), 1918.

SHELDON, PETER John Smith and the *"Question of Water"* Chapter 6. Editor Rory McLeon, University and Community in the Nineteenth Century, Professor John Smith 1821-1885. First published 1988 by The University of Sydney

SNAPE, D.W. & DOWD, R.W. Paper *"Cataract Dam, Remedial Measures".* Presented to ANCOLD 1989 Conference on Dams in Ballarat, Victoria. 13-16 November 1989.

SOUTH AUSTRALIA 1902 Royal Commission into the Port Adelaide Outer Harbour (Thomas Keele).

THORPE, N.J. Water Supply and Sewerage. Fraser, D.J. editor 1989. *"Sydney: From Settlement to City. An engineering history of Sydney".* Engineers Australia Pty Ltd.

WADE, L.A.B. Paper *"The Use of Cyclopean Masonry at Cataract Dam."* Read to the Royal Society in 1908.

WATER BOARD (SYDNEY) Cataract Dam Surveillance Report 1989.

9.0 ABBREVIATIONS:

ANCOLD	Australian National Committee on Large Dams.
ICOLD	International Committee on Large Dams.
JPSCPW	Joint Parliamentary Standing Committee on Public Works (of both Houses of Parliament).
HEM	Historic Engineering Marker (of the Institution of Engineers, Australia).
NEL	National Engineering Landmark (of the Institution of Engineers, Australia).
PWD	Public Works Department of NSW.
WCIC	Water Conservation and Irrigation Commission of NSW

PHOTOGRAPHS:

FRONT COVER — From East Bank looking towards Waste Weir (Spillway).

1. From West Bank looking over Waste Weir (Spillway) to Keele Island and up Sherbrooke Arm. (Power Station was on point of island.) Moulding yard and railway on edge of island.

2. Depth Chart. Indicates rapid storage reduction at lower depths.

3. Completion Plaque above Upper Valve House, 1907. (Transfer stone 1908 nearby and Commemoration Stone 1906 near Lower Valve House).

4. Bench Mark between Castrellations of upstream parapet. Reduced level 960.07 feet. (River Level 800 feet approximately.)

5. Firebox for Boiling Billy. (Backs towards the fire.)

6. Spillway Channel (Bye Wash). Rock hewn from here for Main Wall.

7. Long poles thought to be locally made defence against Dambuster type raids. Flotation Tanks on Keele Island. Holes presumed to be for cable(s). Note pattern of upstream face moulded basalt blocks.

8. *"Dressed"* example of cyclopean masonry, weighting between 2½ to 4 tons.

9. Explosives Magazine, West Bank (above spillway channel).

10. Exposed Railway Formation along Sherbrooke Arm. Note *"Puffing Billy"* type bridge.

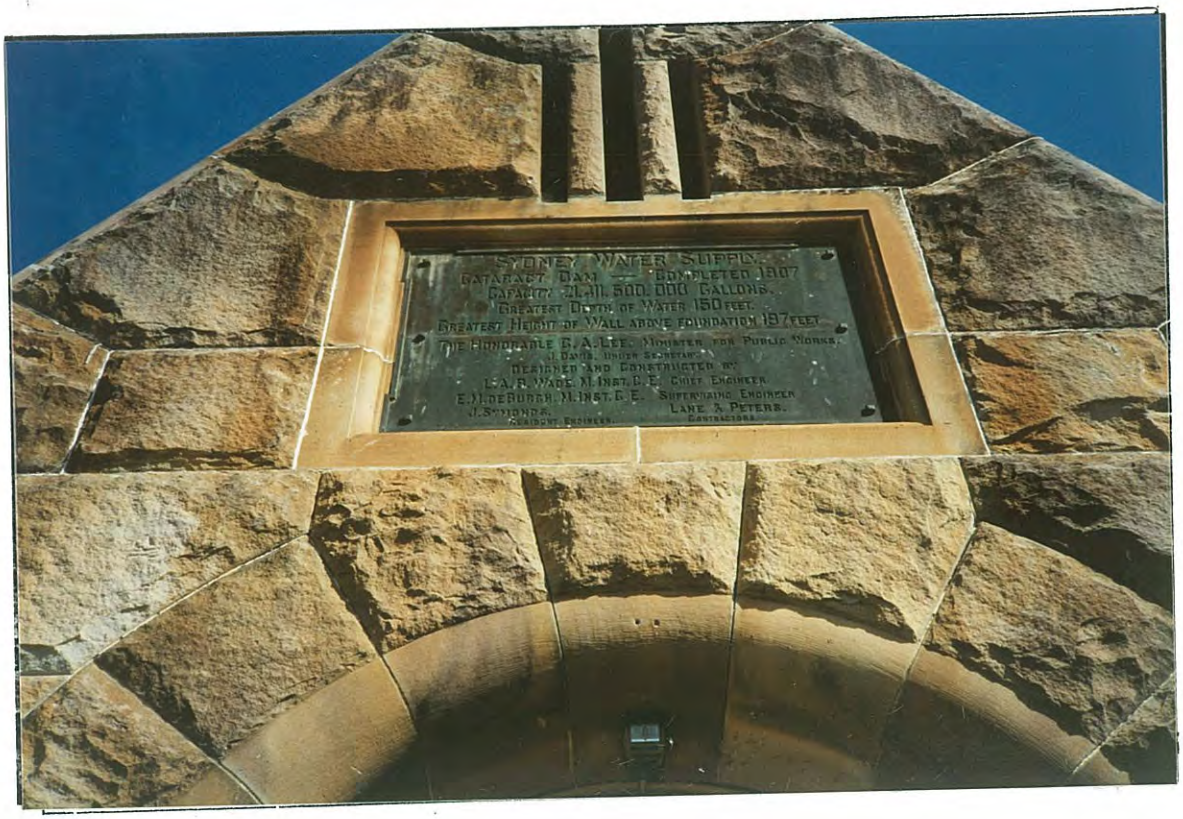
11. Disused *"Gate Type"* Stop Valve. (has been replaced by Ring Follower type Emergency Valve.) Allowed for maintenance/removal of Needle Valve below.

12. Larner-Johnson 30"x24" Needle Valve. *"Needle"* slides along centre line to increase/decrease flow. Powered by water pressure or manually.

1


CATARACT dam
PRESENT STORAGE
*PERCENTAGE
DEPTH IN METRES BELOW TOP WATER LEVEL
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
8
10
15
20
40 5

2


SYDNEY WATER SUPPLY.
CATARACT DAM. — COMPLETED 1907.
CAPACITY 21,411,500,000 GALLONS.
GREATEST DEPTH OF WATER 150 FEET.
GREATEST HEIGHT OF WALL ABOVE FOUNDATION 197 FEET.
THE HONORABLE E. A. LEE, MINISTER FOR PUBLIC WORKS.
J. DAVIS, UNDER SECRETARY.
DESIGNED AND CONSTRUCTED BY
L. A. B. WADE, M. INST. C. E., CHIEF ENGINEER.
E. M. DE BURGH, M. INST. C. E., SUPERVISING ENGINEER.
J. SYMONDS, RESIDENT ENGINEER.
LANE & PETERS, CONTRACTORS.

3


BM 960.07

4

5

6

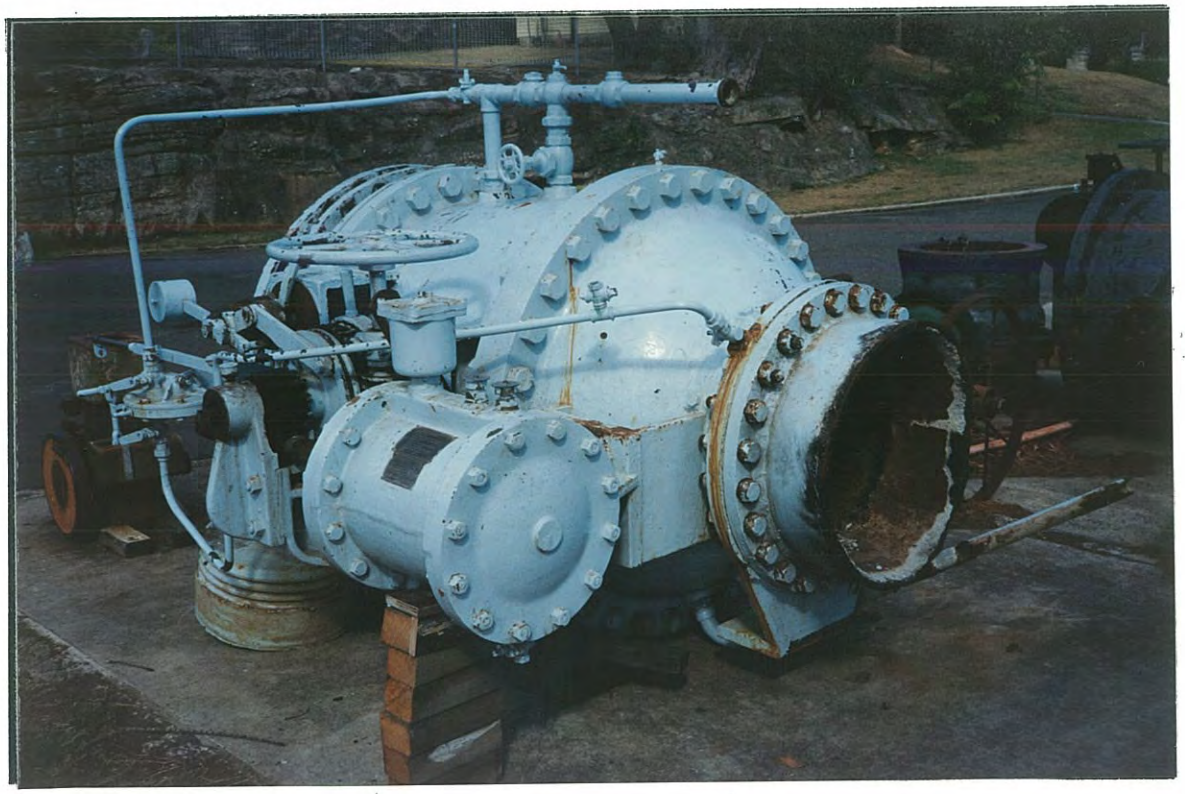
7

8

9

10

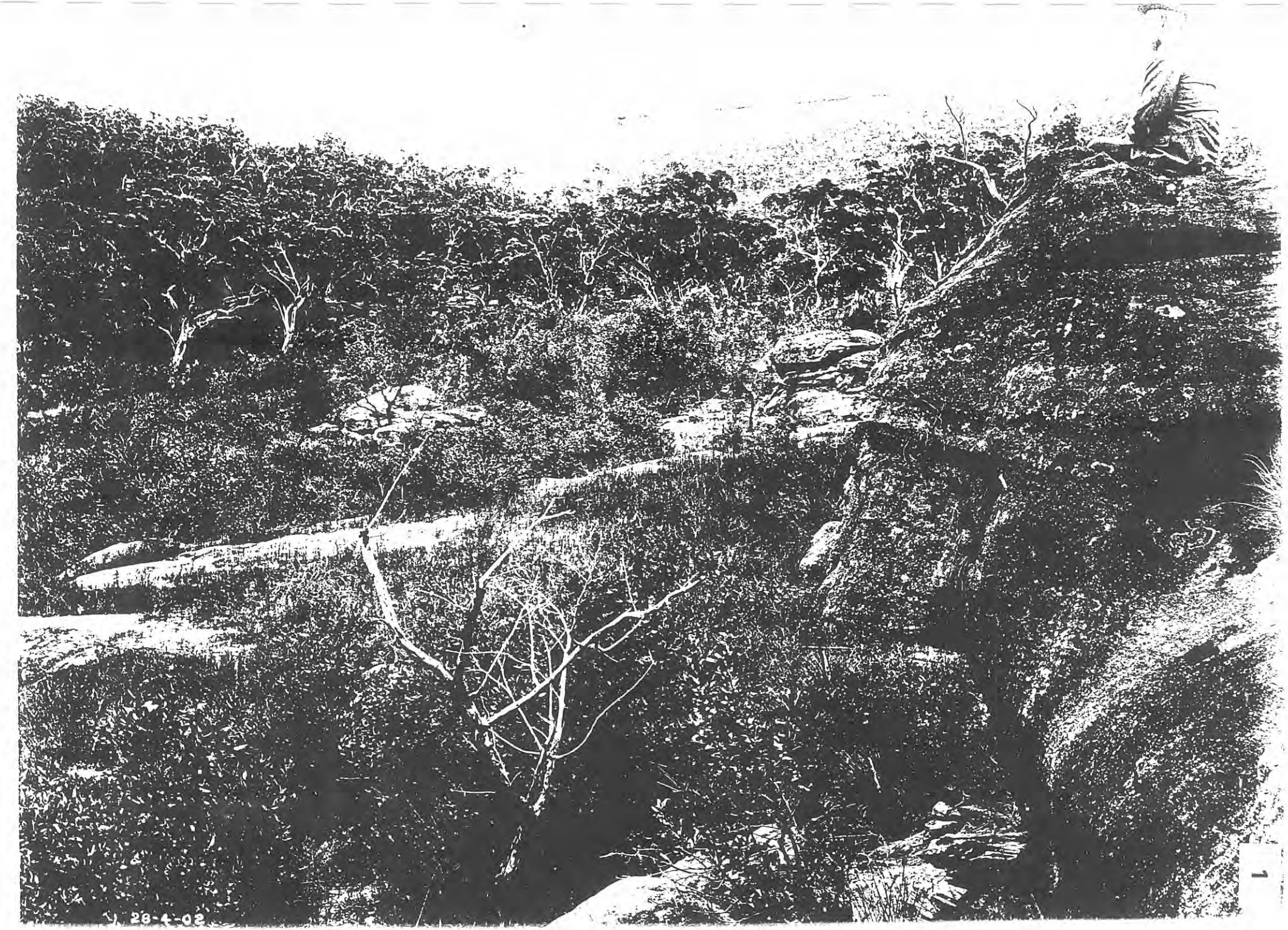
11

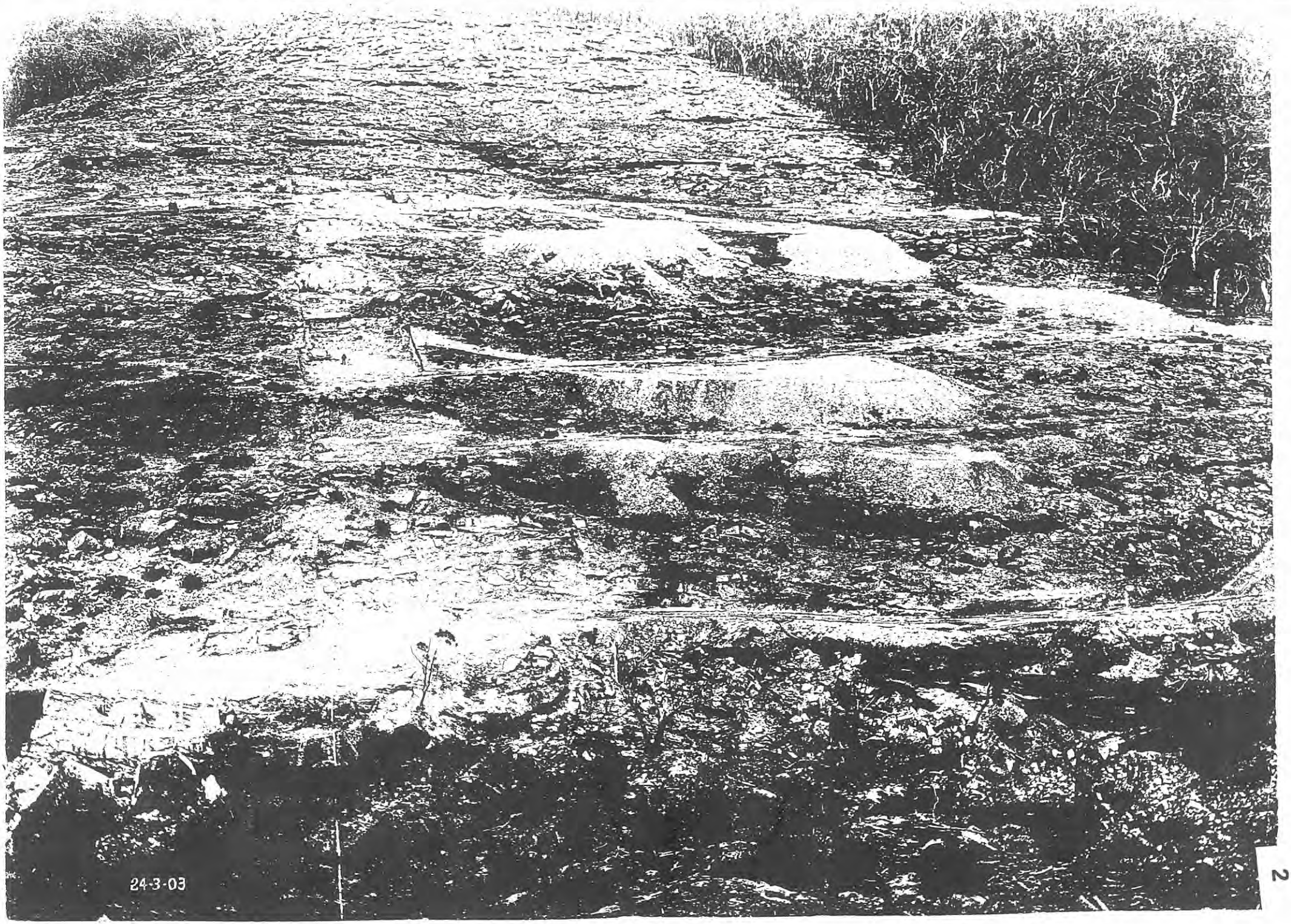


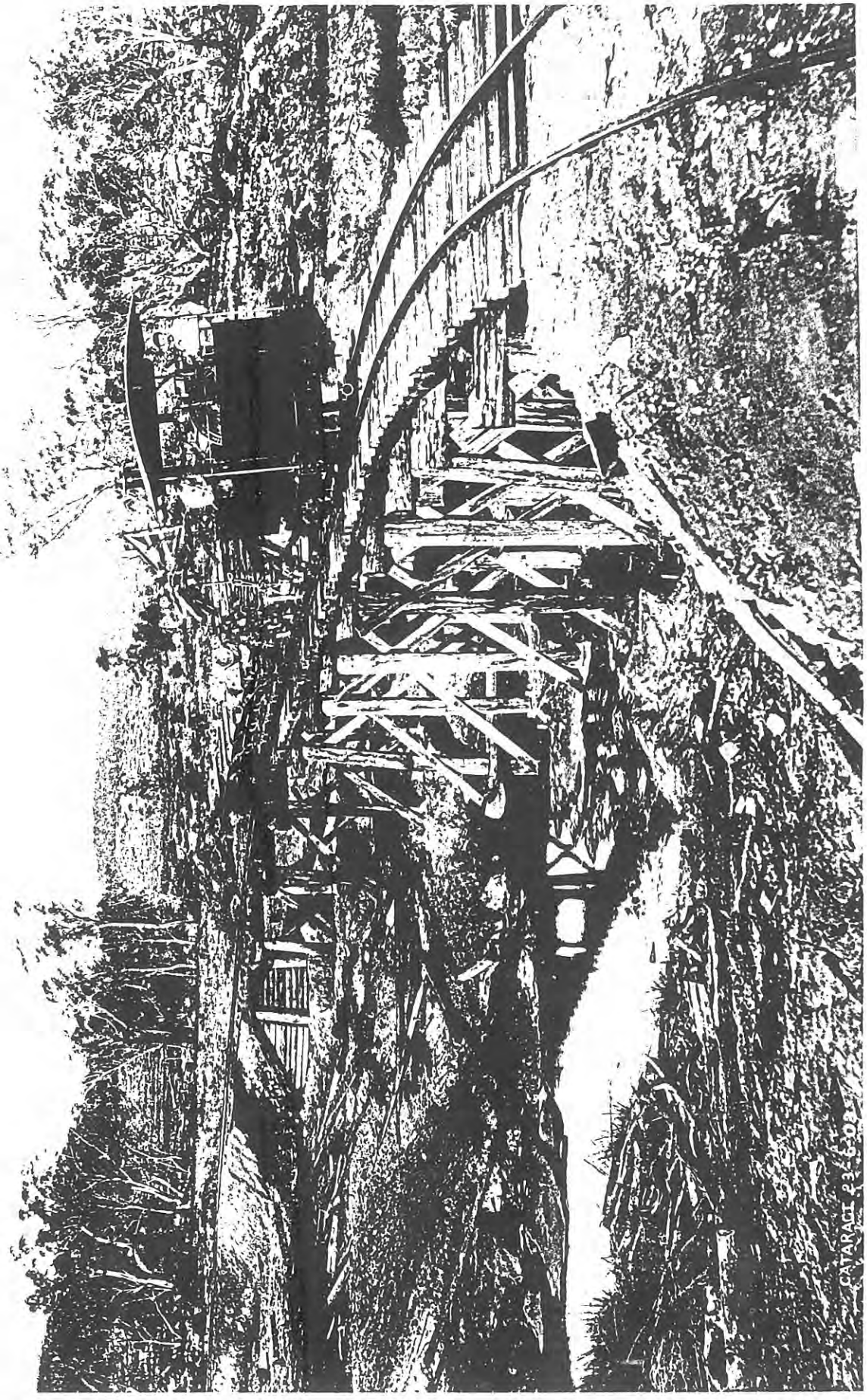
12

HISTORIC PHOTOGRAPHS (Photocopies)

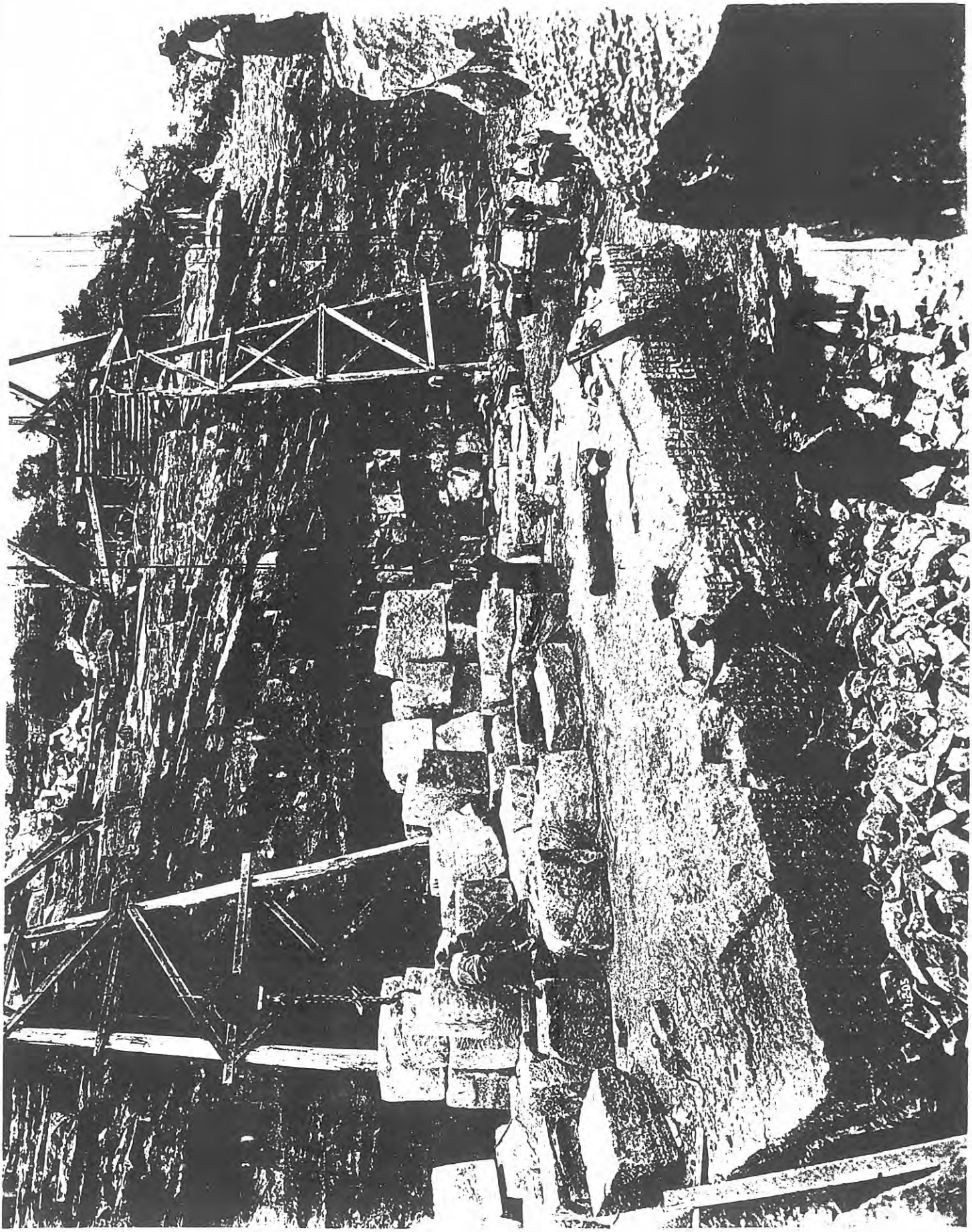
Item	Description	Taken
1.	Before Starting	28/4/02
2.	West Bank. Note shape of dam	24/3/03
3.	"KATE" along Cataract Creek	23/6/03
4.	"Lidgerwood" Winch (N.Y. 1892)	18/2/04
5.	Excavating Foundations	20/5/04
6.	Generator	1/2/05
7.	Foundations ready for Masonry	1/2/05
8.	"Cataract City"	13/3/05
9.	Basalt Moulding Yard	13/3/05
10.	Pressure Grouting	24/8/05
11.	Looking Downstream	13/12/05
12.	Looking Upstream	19/12/05
13.	Upstream Wall (note level of intake)	4/2/06
14.	Flood	1/9/06
15.	Power House (from top of Keele Island)	Undated
16.	Cableway Removed	4/9/07
17.	Just Completed	Undated
18.	Official quarters (build 1910)	Undated
19.	Visit by Governor-General	1916


28-4-02

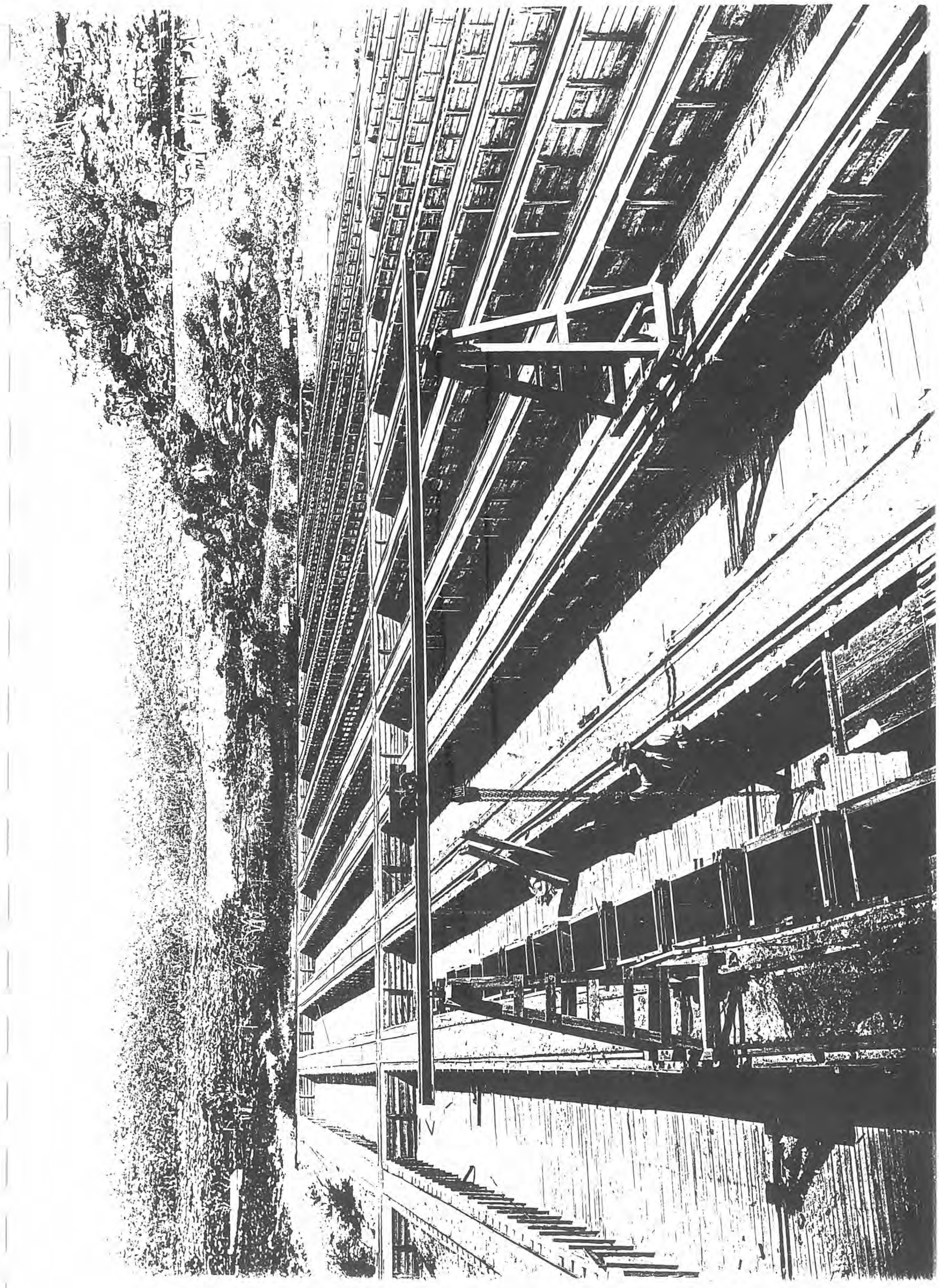

24-3-03


CATARACT 23-502

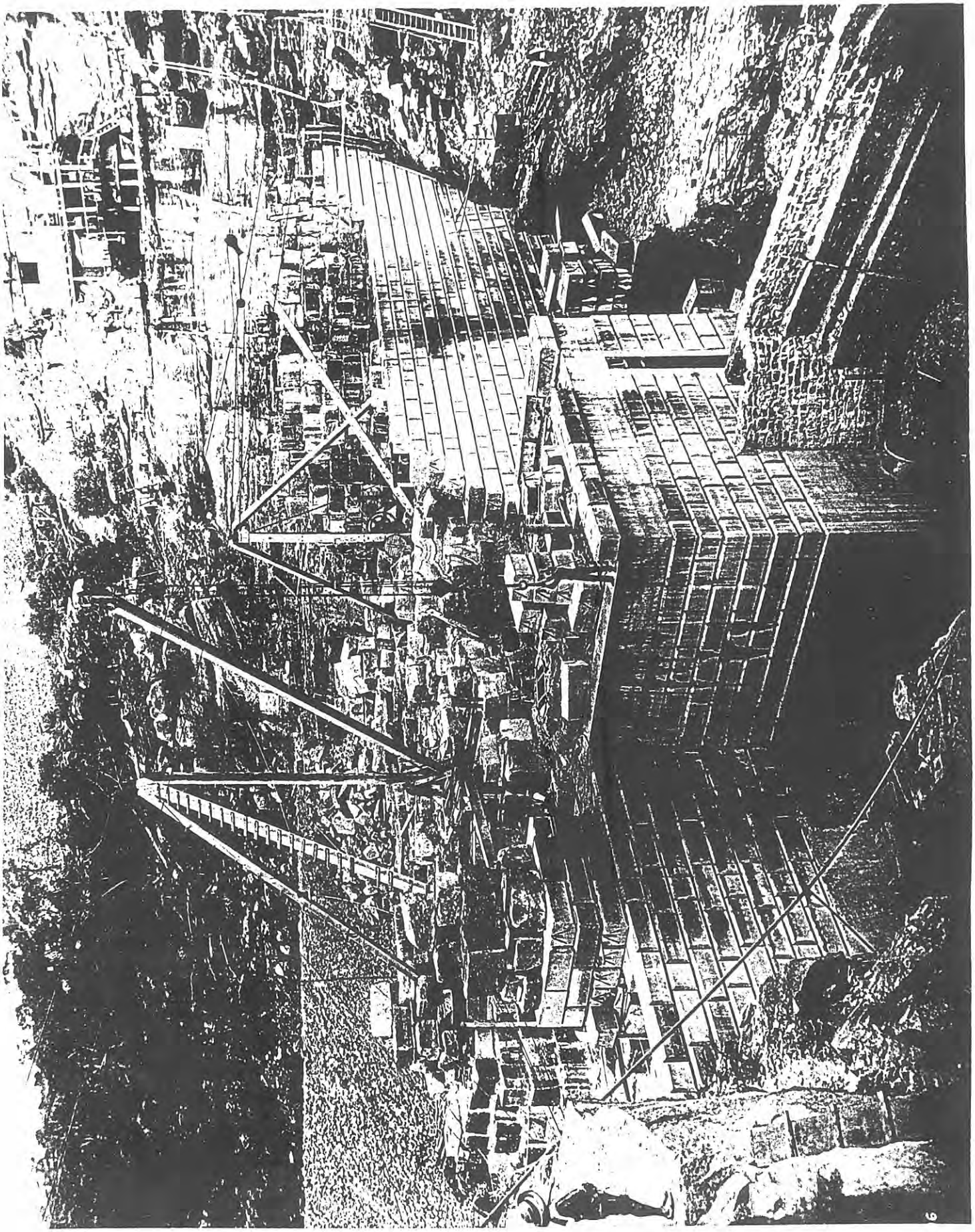
THOMAS PARK

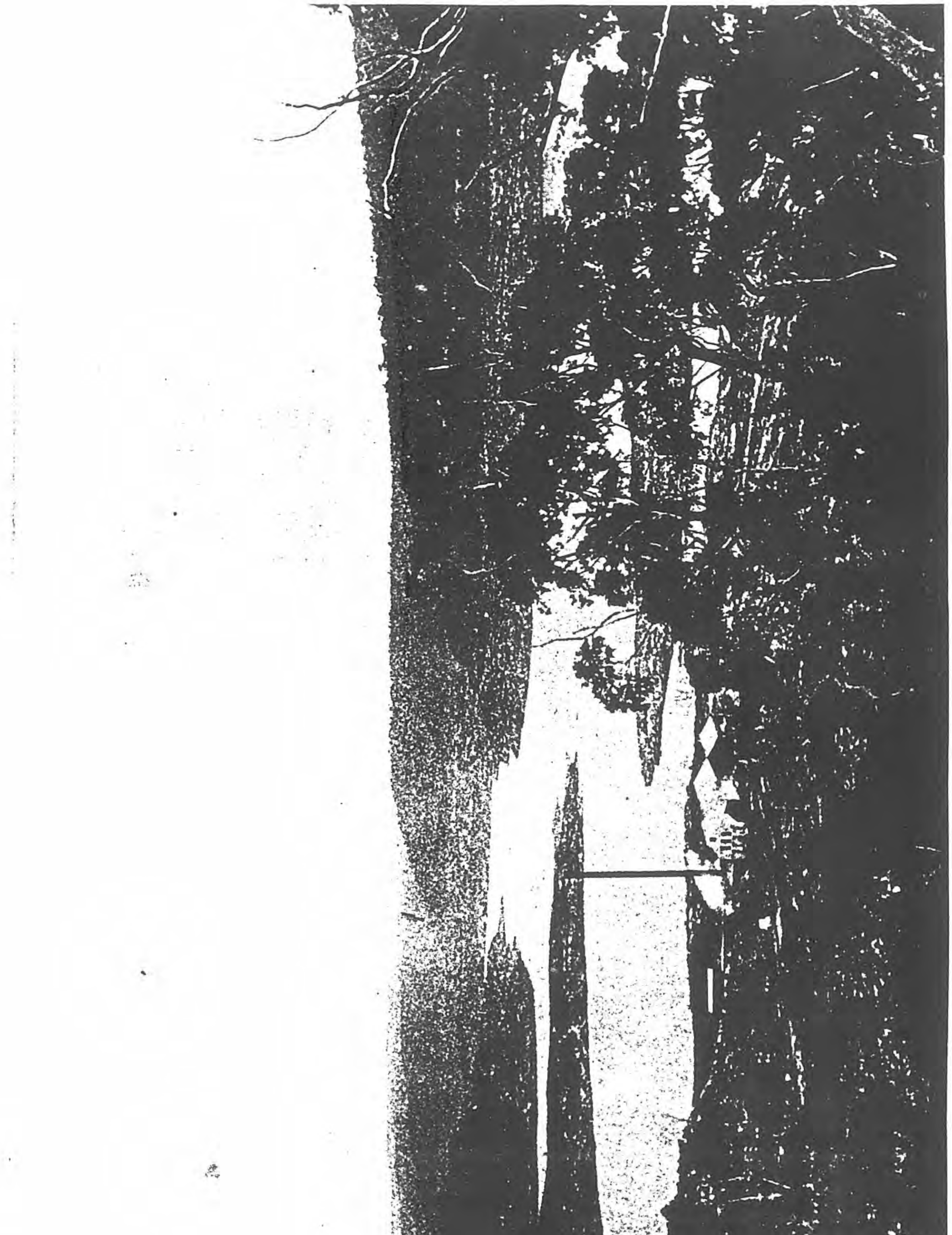


MAIN STREET, CATARACT CITY.
"WAITING FOR THE MAIL"

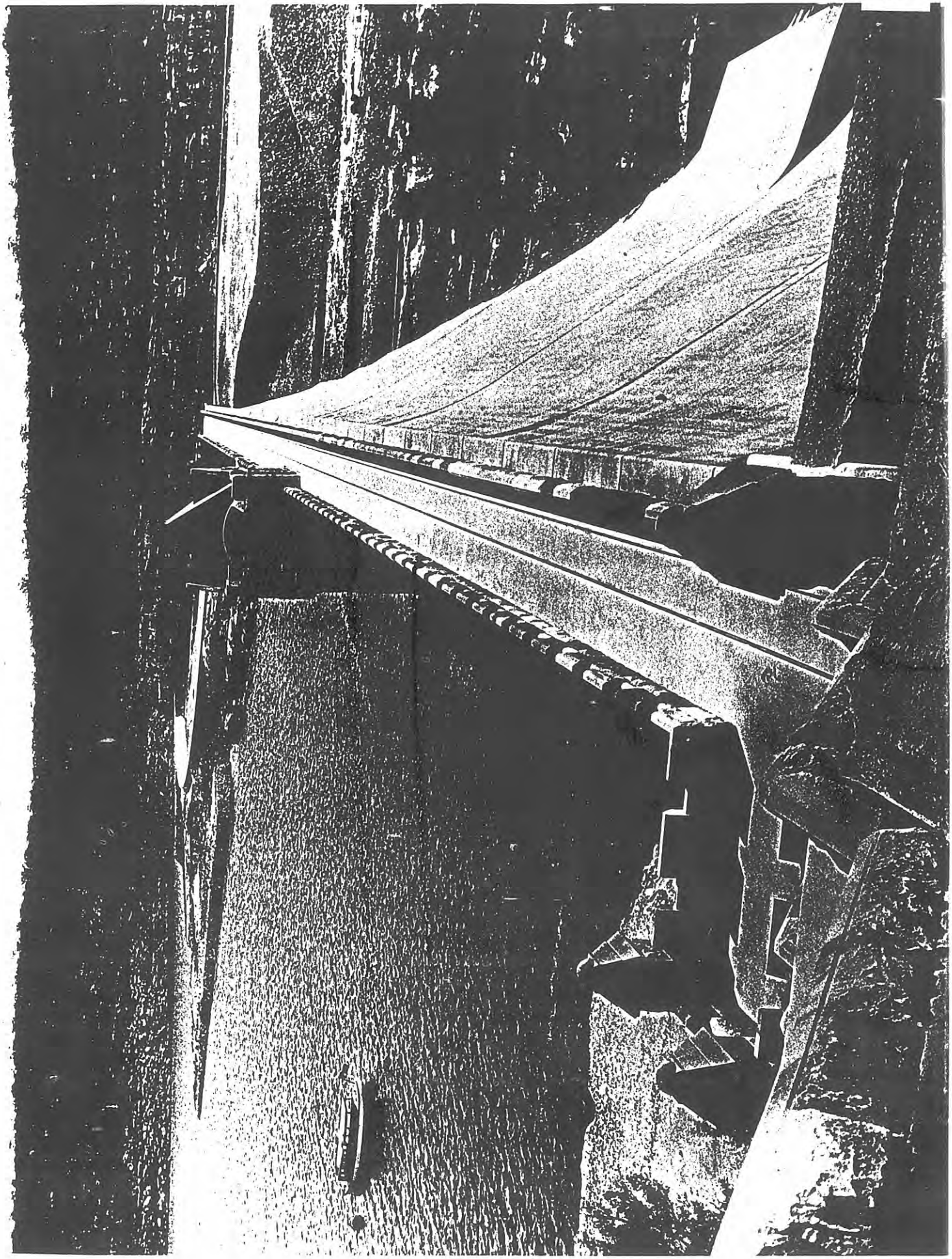


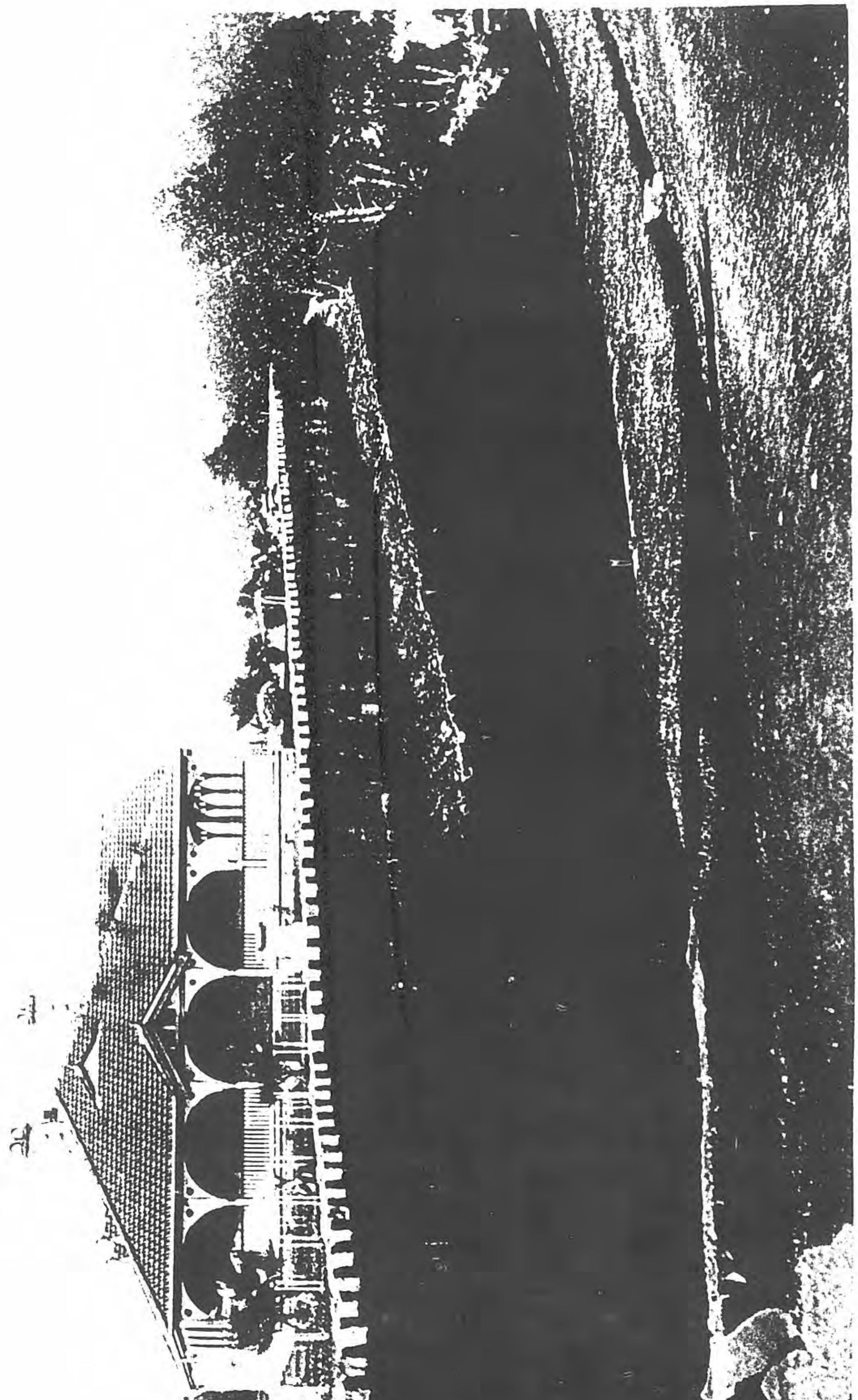
13-12-05

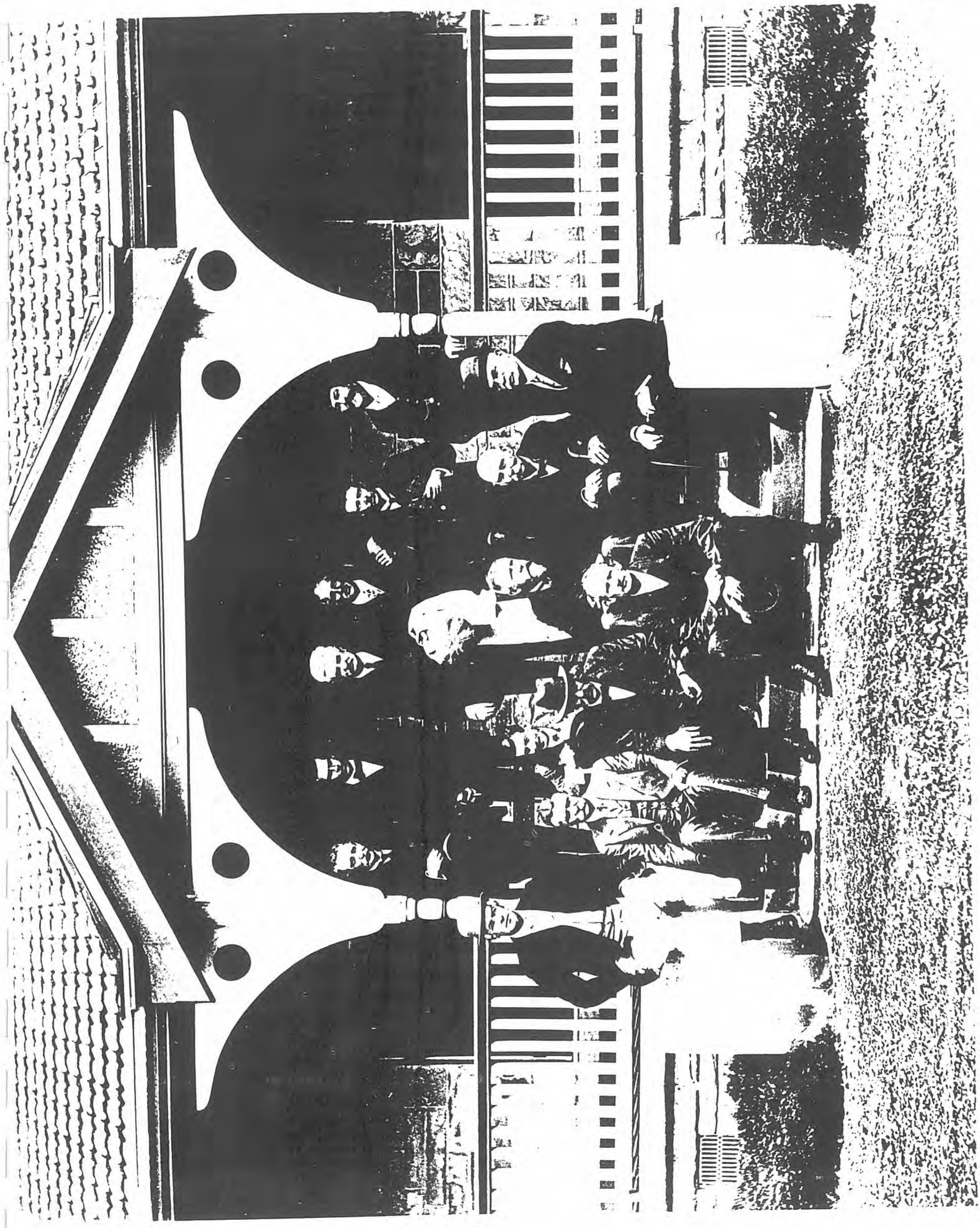




4.9.07







APPENDIX A:

Date	Description	Reference
1852	Report to the Legislative Council	1
1867/69	Sydney Water Supply	2
1876/	Report by Mr. W. Clark	3
1902	royal Commission Sydney Water Supply (3 Reports)	4
1905	Royal Commission into Final Height of Cataract Dam	5
1905*	Royal Commission into the Discrepancy between Estimated Cost and Expected Final Cost	6
1933*	Royal Commission into the Pressure Tunnel	7

* Sample extract attached

1905.

LEGISLATIVE ASSEMBLY.

NEW SOUTH WALES.

REPORT

OF THE

ROYAL COMMISSION

OF INQUIRY

INTO THE DISCREPANCY BETWEEN THE ESTIMATED

COST OF THE CATARACT DAM,

AND THE AMOUNT IT IS NOW ANTICIPATED IT WILL COST TO COMPLETE THE STRUCTURE;

TOGETHER WITH

COPIES OF COMMISSIONS, MINUTES OF PROCEEDINGS, EVIDENCE, AND APPENDIX.

[*In substitution of the Paper laid upon the Table of the House on* 8 *August*, 1905.]

Printed under No. 8 *Report from Printing Committee,* 24 *August,* 1905.

SYDNEY: WILLIAM APPLEGATE GULLICK, GOVERNMENT PRINTER.

1905.

56216 *35—*a* [10*s*.]

TABLE OF CONTENTS.

[COPY OF COMMISSION.]

EDWARD VII, by the Grace of God, of the United Kingdom of Great Britain and Ireland, and of the British Dominions beyond the Seas, King, Defender of the Faith, Emperor of India.

To Our Trusty and Well-beloved

GEORGE ALEXANDER WILSON, Esquire,

Chairman of the Public Service Board, and one of Our Justices of the Peace of Our State of New South Wales.

GREETING:—

KNOW you, That We, reposing great trust and confidence in your ability, zeal, industry, discretion, and integrity, do, by these Presents, authorise and appoint you to make a diligent and full inquiry into the discrepancy between the Estimates submitted to the Public Works Committee and placed before Parliament for the building of the Cataract Dam, as authorised, and the amount it is now anticipated it will cost to complete the structure: And, in order that your conclusions may directly bear upon the points which require determining, the following issues are included in the Commission:—

In your opinion:

(I) *What will be the probable cost of dams having respective heights of* 145 *feet and* 150 *feet to top-water level?*

(II) *What are the reasons, and what Officers, if any, are responsible for the difference of the probable cost as arrived at under question 1 of the dam* 150 *feet high and the estimated cost sanctioned by Parliament in Act No.* 87, 1902, *on the recommendation of the Parliamentary Standing Committee on Public Works, contained in the following resolution:—"That, in the opinion of the Committee, it is not expedient the proposed concrete dam across the Cataract River, as referred to them by the Legislative Assembly, be carried out; but the Committee recommend the construction of a dam, as designed by the Principal Engineer for Harbours and Rivers,* 160 *feet high, to impound* 18,200 *million gallons of water at a cost not exceeding* £217,500."

AND We do, by these Presents, grant to you full power and authority to call before you all such persons as you may judge necessary, by whom you may be better informed of the truth in the premises, and to require the production of all such books, papers, writings, and all other documents as you may deem expedient, and to visit and inspect the same at the offices or places where the same or any of them may be deposited, and to inquire of the premises by all lawful ways and means: And Our further will and pleasure is that you do, on or before the twentieth day of April proximo, certify to Us, in the Office of Our Secretary for Public Works, under your hand and seal, what you shall find touching the premises: And We hereby command all Government Officers and other persons whomsoever within Our said State, that they be assistant to you in the execution of these Presents: And We do hereby declare this Our Commission to be a Commission for all purposes of the Act No. 23, 1901, *intituled "An Act to consolidate the law relating to the taking of evidence by Commissioners under the Great Seal."*

In testimony whereof, We have caused these Our Letters to be made Patent, and the Public Seal of Our said State of New South Wales to be hereunto affixed.

Witness Our Trusty and Well-beloved Sir HARRY HOLDSWORTH RAWSON, Admiral in Our Royal Navy, Knight Commander of Our Most Honorable Order of the Bath, Our Governor of Our said State of New South Wales and its Dependencies, in the Commonwealth of Australia, at Sydney, in New South Wales aforesaid, this thirteenth day of March, in the fifth year of Our Reign, and in the year of Our Lord one thousand nine hundred and five.

(Sgd.) HARRY H. RAWSON,
Governor.

By His Excellency's Command,

(Sgd.) J. A. HOGUE.

Entered on Record by me, in REGISTER OF PATENTS, No. 25, *page* 361, *this fourteenth day of March, one thousand nine hundred and five.*

For the Colonial Secretary and Registrar of Records,

(Sgd.) J. GIBSON,
Under Secretary.

ROYAL

ROYAL COMMISSION TO INQUIRE INTO THE COST OF THE CATARACT DAM.

WHEREAS it is necessary to extend the time within which the Commissioner is to make his Report in the above matter: Now, therefore, I do hereby, with the advice of the Executive Council, extend the time within which the said Commissioner is to make such Report until the 20th day of June next.

Given under my hand at Sydney, this twentieth day of April, one thousand nine hundred and five.

By Deputation from His Excellency.

(*Syd.*) ***FREDK. M. DARLEY,***
Lieutenant-Governor.

By His Excellency's Command,
J. A. HOGUE.

ROYAL COMMISSION TO INQUIRE INTO THE COST OF THE CATARACT DAM.

WHEREAS the time appointed for the return of the Commission in the above matter was by an Instrument dated the twentieth day of April last extended until the twentieth day of June instant: And whereas it is necessary to extend the same still further: Now, therefore, I do hereby, with the advice of the Executive Council, further extend the time within which the Commissioner is to make his Report until the thirty-first day of July next.

Given under my hand at Sydney, this fourteenth day of June, one thousand nine hundred and five.

(*Syd.*) ***FREDK. M. DARLEY,***
Lieutenant-Governor.

By His Excellency's Command,
J. A. HOGUE.

HEADINGS OF REPORT.

NOTE.—For list of witnesses alphabetically arranged see page 11 of Report.

the foundations below the surface, both in the river channel and on the sides of the gorge, together with the prices allowed for certain items in the work, were much under-estimated by the President of the Water Supply and Sewerage Board (then Principal Engineer for Harbours and Rivers), and that the total cost, when completed, of the structure with the necessary additions is now estimated to be £350,000."

Minute of Minister for Public Works.

5. The Minister's minute contained a further passage, as follows:—"The project was always viewed as one of storage for the benefit of the metropolitan residents only, and as such it has been designed and provided for; but I much regret to find that, notwithstanding the economy that will be exercised, even the erection of a 145-foot dam to impound the statutory quantity of water insisted upon by Parliament, will cost at least £132,000 in excess of the amount voted by the Legislative Assembly, and this latter amount, I am reluctantly compelled to add, was determined upon by the estimate and evidence of the then Principal Engineer for Harbours and Rivers (Mr. Keele), thus showing conclusively that he has misled, not only the Committee, but the Parliament of the country."

Royal Commission appointed re cost of dam.

6. On the 13th of March your Commissioner was appointed to inquire into the excess of the probable cost over the estimated cost, and the responsibility for such excess.

II. The Course of the Inquiry.

Technical questions excluded unless bearing on cost.

7. At the opening sitting your Commissioner stated that he viewed the subject of inquiry as being purely a business matter—his duty being to ascertain certain business facts—and he considered that, if it had been intended that professional (engineering) questions should be investigated, a professional expert would have been appointed to conduct the inquiry. Therefore, if professional matters were introduced during the course of the investigation, he would not admit them, unless it could be shown to him that such professional matters would have a direct bearing upon the specific questions which, by the Commission, he was asked to answer.

Mr. D. C. Simpson, M.I.C.E., appointed to assist Commissioner.

8. In view of the fact that some technical matters were, however, almost certain to be imported into the inquiry (as, indeed, has proved to be the case), your Commissoner decided to ask for the assistance of an engineer of good professional standing, and having no connection with either the Public Works Department or the Water and Sewerage Board, to sit with him during the proceedings and to advise him on any technical questions which might arise. By the courtesy of the Railway Commissioners, Mr. D. C. Simpson, M. Inst. C.E., was appointed, and has acted in this capacity throughout the inquiry and during the preparation of this Report.

Inquiry open to Press.

9. The subject of the inquiry having aroused great public interest, and the circumstances which led to the appointment of a Commission to investigate the excess of the probable cost of the Cataract Dam over the original estimate, and the responsibility therefor, having been widely published, your Commissioner decided at the outset that the proceedings should be of a public character. The inquiry has therefore throughout all its stages been open to the Press.

Parties to inquiry.

10. The parties to the inquiry were, on the one hand, Mr. Keele; and, on the other, the Department of Public Works, the officers of that Department specially concerned being the Under Secretary (Mr. J. Davis), the Principal Engineer for Rivers, Water Supply, and Drainage (Mr. L. A. B. Wade), and the Resident Engineer at Cataract Dam (Mr. J. Symonds). At the opening meeting your Commissioner informed the parties that, if they so desired, they might have the assistance of counsel. Taking advantage of this permission, the Department of Public Works was represented by Mr. W. Robison, of the Crown Solicitor's Office, while Mr. Keele was represented by Mr. H. S. Williams, Solicitor to the Metropolitan Board of Water Supply and Sewerage.

Parties allowed assistance of counsel.

Sittings of Commission.

Inspection of dam.

11. The first sitting of the inquiry was held on the 17th of March, and on the 22nd of March a visit of inspection was paid to the site of the dam, near the confluence of Cataract Creek and Cataract River. Further meetings were held on the 27th and 31st of March, but the proceedings were only of a preliminary and formal

day-labour work there and could not get away for a little time as he had to clear up his work and accounts, so that at the beginning of the work Mr. Symonds had to do work on the dam that was a considerable tax on his time, and had to do his other work at night. It was about a week or ten days before Mr. Thackeray was sent to Cataract. There had been no chopping and changing about with regard to the inspection.

390. In reply to Mr. Keele, Mr. Wade said Mr. Ironside was a competent inspector; if he got instructions he could carry them out explicitly. The quarry foreman, Mr. Flew, was never in charge of the laying of the stone; he was in charge of the excavation. The foreman on the masonry was Mr. Waghorn, who had been in the quarry. Mr. Waghorn had been engaged on concrete work in the Sydney sewerage construction; he was a first-class concrete man. The masonry work started on the 29th January, and Mr. Thackeray was sent on the 6th February—there were only eight days between. Mr. Weedon was the engineer now in charge of the work. Mr. de Burgh was never in charge, but visited the work frequently, in order to have more frequent inspection from head-office than he (Mr. Wade) was able to give. Mr. Weedon was sent there while Mr. Symonds was absent attending the Commission. There was no inspector there acting as an inspector for eight days. Mr. Keele had taken exception to Mr. Symonds being there, as he had doubts as to his experience. Mr. Wade had not heard anybody else express that opinion. There had been no chopping and changing about in the matter of inspection. (Qs. 2792–2817, 11665–77, 10375–95, 11603–54.)

Conclusions.

391. Your Commissioner, after careful consideration of the evidence, is of opinion that there was no "chopping and changing" in connection either with the management or the inspection. Certainly, Mr. Weedon has been placed in charge as acting Resident Engineer during Mr. Symonds' absence from the work while attending your Commissioner's inquiry, but it is hardly generous for Mr. Keele to rely on this circumstance as affording ground on which to base such an allegation. Mr. de Burgh, as the evidence shows, was not sent to Cataract to replace Mr. Symonds, but, as Mr. Wade's principal assistant, to afford more frequent supervision from head-office than Mr. Wade alone could give. *No "chopping and changing."*

392. The delay of eight days between the commencement of the building of the dam and the arrival on the works of Inspector Thackeray, did not, in your Commissioner's opinion, prejudice the work as suggested by Mr. Keele, as, pending the inspector's arrival, Mr. Symonds and Mr. Ironside attended to the inspection, and as Mr. Wade points out, an inspector's supervision cannot well be better than that of the engineer from whom he takes his instructions—provided both are equally attentive to their duties. That there was no want of foresight exhibited is shown by the fact that arrangements were made some months in advance to secure the services of the best inspector in the Department; and the circumstance that there was a delay of a few days in his arrival on the work after his services were required, though productive of some inconvenience by reason of the extra strain thrown on the resident engineer, is not a matter for which Mr. Wade or Mr. Symonds should be criticised. *Inspectors.* *No want of foresight.*

393. With regard to the allegation that the inspectors were incompetent to perform the duties required of them, your Commissioner finds that competent officers were employed. **It must not be forgotten that the Cataract Dam is the largest work of its kind in the Southern Hemisphere, and that work of a similar character and magnitude has not previously been carried out anywhere in Australia.** It would not be possible, therefore, for the Department to obtain inspectors who had had previous experience of exactly similar work. The officers employed, however, who are competent men, had the advantage of consulting the Resident Engineer, the Principal Assistant Engineer, and Mr. Wade, the two latter of whom have recently inspected large works in Britain and America respectively—and with this assistance the inspectors could quickly become thoroughly conversant with the character and quality of work required, and see that it is properly carried out. *Inspectors were competent.*

394.

Mr. Symonds' appointment as Resident Engineer.

394. Though still a young man Mr. Symonds has served the Department of Public Works in an engineering capacity for fourteen years: he has had charge, as Resident Engineer, of the construction of several concrete dams in various parts of the State, among which are those at Cootamundra and Wellington, and has had valuable experience in the employ of contractors. In the execution of the works referred to he has won for himself the reputation of always carrying out his works at a cost within the estimate. It is to be noted that the officer required to fill the position of Resident Engineer at Cataract Dam would be required to act, not only as engineer, but also as contractor. Upon him would devolve under the day labour system the responsibility of laying out the work, engaging the labour, dealing with the workmen, disposing of the plant and labour to the best advantage for the work, acting as paymaster, attending to accounts and finance, laying out and superintending the workmen's camp, arranging for a sanitary service and water supply for the camp, and arranging and enforcing upon the workmen the observance of a strict sanitary code in order that the water of the river, which flows into the Sydney water supply, should not be polluted—in addition to his work as engineer in supervising the construction of the dam. Seeing that Mr. Symonds had had experience with contractors, and that his record was such as has been described, your Commissioner considers that his appointment to take charge of the construction of the Cataract Dam was justified, and that, judging by the evidence, he appears to have acted throughout entirely in the best interests of the Department.

(*xi*) *Inexperience and Want of Foresight.*

Conclusions.

No want of foresight or inexperience.

395. Each of the matters on which Mr. Keele based his charges of inexperience and want of foresight against Mr. Wade and Mr. Symonds has been separately considered in the preceding paragraphs; and, as the result, your Commissioner finds the charges have been disproved, and that Mr. Wade and Mr. Symonds have exercised foresight and judgment in carrying out this important work.

XII. Probable Cost of Dam—Decision on Issue No. 1.

Tenders for completion of dam.

396. After your Excellency had issued the Commission empowering your Commissioner to conduct this investigation, tenders were publicly invited for the completion of the dam, and that of Messrs. Lane and Peters was accepted. This fact has, therefore, simplified the task laid upon your Commissioner of ascertaining what would be the probable cost of the present structure. In the first place, the Department of Public Works have expended the sum of £65,122 10s. 2d. in the work of clearing, excavation, laying the hearting of the foundation, and in supervision; secondly, the work to be carried out by the contractors will cost, at the rates of their tender, £183,766 18s. 3d., and there is work still to be done by the Department, apart from the contract, which, together with the supply of cement to the contractors, it is estimated will cost £73,561 2s. 4d., while the supervision and contingencies are estimated at £19,200, making a total of £341,650.

Credit for plant.

397. The full cost of the plant installed on the works has, however, been taken as a debit against the work in these figures, as though it would be worn out by the time the work is completed. This plant, however, is new, is of modern design and construction, and is in good order and condition, and, as a matter of fact, the greater portion of it should, if properly taken care of, as foreshadowed by Mr. Wade, be capable of many years' useful service on other works of importance. The Department, therefore, contend that the gross expenditure as stated above should be reduced by a credit allowance for the estimated value of the plant at the completion of the work; and in this contention your Commissioner fully agrees. In the opinion of several contractors who gave evidence on this point, 50 per cent. only of the cost of the plant should be charged against the dam. Adopting this view, which, to your Commissioner seems a reasonable one, the gross cost should be reduced by the sum of £16,553 12s. 6d. (half the cost of the plant, excluding erection).

398. There is, however, another item of cost chargeable against the dam which is not shown on the departmental statement, viz., the sum of £400, which is the estimated cost of diverting the low discharges of the Cataract River so that they may not flow into Prospect Reservoir during the construction of the dam—this expenditure being decided upon in preference to removing the workmen's camp from its present site within the catchment area, as has been previously pointed out in this Report. *Camp site.* *Diversion of low discharges of Cataract River.*

399. The probable cost of the dam may, therefore, be arrived at as follows:— *Probable cost of 150 feet. dam.*

				£ s. d.
Work done by Public Works Department by day-labour and piece-work :—				
Clearing site	£16,008	0	4	
Excavation	33,983	2	11	
Body of dam ("concrete")	12,089	5	4	
Outlet works	*Nil.*			
Supervision and contingencies	3,042	1	7	
				65,122 10 2
Work to be done by Contractors :—				
Excavation	£21,510	17	0	
Body of dam ("concrete")	160,084	3	7	
Outlet works	471	17	8	
Contingencies	1,700	0	0	
Supervision	*Nil.*			
				183,766 18 3
Work outside contract to be done by Department :—				
Clearing site	£5,286	4	0	
Excavation	*Nil.*			
Body of dam ("concrete"). (Supply of cement only)	63,821	10	0	
Outlet works (supply of ironwork and valve-house)	4,453	8	4	
Supervision and contingencies	19,200	0	0	
				92,761 2 4
Diversion of Low Discharges of Cataract River—due to wrong location of camp				400 0 0
Gross cost				£342,050 10 9
Less allowance of 50 per cent. on £33,107 5s. 1d., the prime cost of plant				16,553 12 6
Probable net cost of Dam				£325,496 18 3

400. Having thus ascertained the probable cost of the dam with a top-water level of 150 feet from the river-bed (the present structure), your Commissioner has no difficulty in answering the second question raised in Issue No. 1, *i.e.*, as to the cost of a similar dam with a top-water level of 145 feet. Both Mr. Keele and Mr. Wade agree that the difference in cost between the two dams would be about £24,000, so that your Commissioner finds that the probable cost of the 145 feet top-water level dam would have been £301,496 18s. 3d. *Probable cost of 145 feet dam.*

XIII. Comparative Statement showing the Excess of Probable Cost over Estimated Cost, and the responsibility therefor.—Decision on Issue No. 2.

401. The second issue on which your Commissioner has to decide is,—What are the reasons, and what officers, if any, are responsible for the excess of the probable over the estimated cost of the dam with 150 feet top-water level. These questions have been fully dealt with in the preceding paragraphs of this report. Your Commissioner proposes therefore to put his reply to this Issue in the form of a concise comparative statement, showing—(i) the original estimate; (ii) the probable cost; (iii) the amount of the excess of column ii over column i; and (iv) the responsibility for such excess. The statement is as follows:— *Excess cost and responsibility therefor.*

(i) Mr. Keele's Estimate		(ii) Cost of Work done and probable Cost of Work to be done.		Excess of Cost over Estimate.		Officers responsible for Excess of Cost over Estimate.	Where dealt with in Report.
Particulars.	Amount.	Particulars.	Amount.	Amount of Excess Cost.	Explanation of what the Excess consists of.		
	£		£ s. d.	£ s. d.			PAGE.
...e of site—1,700 acres, at ...r acre.	8,500	Clearing of Site—2,456 acres, at £8/12/7.	21,294 4 4	12,794 4 4	(1) Excess of area of 756 acres, consisting of— (*a*) Omission of 300 acres from original survey ..... (*b*) Clearing of 456 acres above top water level of reservoir, not provided for by Mr. Keele when preparing his estimate.	Surveyor McTaggart, of Metropolitan Board of Water Supply and Sewerage. Mr. Wade; but Mr. Keele admits that the clearing of this would be necessary for the protection of the dam. There is no authority under the Act for clearing it.	26 27-32
					(2) Excess of cost per acre, of £3 12s. 7d., arising from— (*a*) Underestimate to the extent of £2 4s. 6d. per acre, due to— (i) Misdescription of timber by Mr. Halligan, and omission from his estimate of provision for snagging. (ii) The clearing being done as "Yankee grubbing" instead of "stump-high" clearing.. (*b*) Excess of cost over a fair price for the character of work done of £1 8s. 1d., due to— (i) The work being done as "relief" work for the unemployed, instead of by bushworkers accustomed to clearing. (ii) The fact that, owing to the prospects of a water famine in 1902, there was a comparative panic, and the public pressure caused the Department to commence work before they were ready to go on with the building of the dam.	Mr. Halligan. Mr. Wade. Ministerial policy. The public pressure on the Department	29, 30-32 27, 28-32 31, 32 30, 31, 32
...tion—Foundations; gul- ...,500 cubic yards, at 6s.; ...of dam, 29,000 cubic yards, ...s. (less 29,000 cubic yards ...used in concrete).	390	Excavation — Foundations; 46,388 cubic yards, at 8s. 0·2d.; 13,210 cubic yards, at 14s. 9·2d.; trenching, 300 cubic yards, at 15s. 3d.; guttering, 1,000 square feet, at 2s. 6d.	28,700 19 9	28,300 19 9	(1) Excess of quantity excavated (60,898 cubic yards) over estimated quantity (30,300 cubic yards) of 30,598 cubic yards—due to the fact that a rock suitable to base the dam upon was not found at the estimated depth, viz., 10 feet, so that the excavation had to be carried down for an additional 20 feet. NOTE.—The greater cost per cubic yard naturally follows upon the greater depth.	Could not be foreseen. Even numerous bores would not give absolutely certain indications over the whole surface.	33
...tion — By-wash; 32,400 ...c yards at 3s. (less 2,000 ...c yards, at 4s., used in ...rete).	4,460	Excavation—By-wash; 113,750 cubic yards, at 2s. 8·36d.; 34,398 cubic yards, at 6s. 6·26d.	26,524 11 2	22,064 11 2	(1) Excess of 115,658 cubic yards of excavation over the estimate, due to— (*a*) Alteration of design of by-wash and waste weir, enlarging and extending them. (*b*) Unnecessary excavation in by-wash, consequent on the lowering of proposed height of dam. NOTE.—For explanation of difference in cost per cubic yard, see body of report, pars. 128-131.	Mr. Wade: But this is a modification under the schedule; and there is a set-off. (See paragraph 44 of report). Mr. Wade: But the excavation was not all unnecessary, and there is a set-off for a portion of it.	16-19 19-21
...ations—Tunnels	Nil.....	Excavation Tunnels; 26 cubic yards, at £2; 52 cubic yards, at £4 3s. 3d.	268 9 0	268 9 0	Mr. Keele may be considered to have provided for this under "Contingencies."		
...te, 112,100 cubic yards, at	179,360	Concrete (including Nos. 1, 2, 3, and 4 concrete, rendering, facing blocks, hearting, rubble masonry, sandstone coping, filling, carriage of materials, cement, materials in stock, and value of materials at schedule rates).	235,994 18 11	56,634 18 11	(1) Excess of cubic quantity of 32,676 cubic yards over estimate, due to— (*a*) Elimination of Mr. Keele's proposed spillway from the design, which now provides for the dam to be of uniform height for the whole of its width. (*b*) Extension of waste weir rubble wall, due to extension of by-wash. (*c*) Provision of rubble training wall along inner edge of by-wash to conduct water to a distance from dam before allowing it to discharge, thus eliminating danger to toe of dam. NOTE.—Estimated cost of *a*, *b*, *c*, £9,022 18s. 11d. approximately. (*d*) Extra bulk of dam due to foundations being 20 feet deeper than was anticipated (estimated cost £47,612 approximately). NOTE.—The cost per cubic yard is, as will be seen, practically the same as Mr. Keele's estimated cost per cubic yard. For the corrected cost per cubic yard (see paragraphs 194-5 of report.)	Mr. Wade is responsible for this; but he shows a set-off by a reduction in another direction of the cubic contents of the dam. (See paragraph 44 of report.) Mr. Keele, however, admits that he would have adopted similar precautions to those under the heading (*c*), at an estimated cost of £6,500, to protect the toe of the dam. The estimate of 10 feet for the depth of foundations made by various officers was a reasonable one under the circumstances, and under the conditions disclosed on the surface.	16-19 38, 39 38, 39 45-47
...t works (apparently iron- ...rk only).	5,000	Outlet works (fixing ironwork, carriage of ironwork, ironwork supplied, ironwork to be supplied, and valve house).	4,925 6 0	.....	NOTE.—It will be seen that, for this item, the probable cost is £74 14s. below the estimate. (See paragraphs 199-206 of report for remarks *re* "concrete," &c., in outlet works.)		
...rvision and Contingencies—10 per cent.	19,790	Supervision and Contingencies (including maintaining road, cleaning up site, pumping water, and insurance.)	23,942 1 7	4,152 1 7	The Department have included a charge for Head Office expenses at the rate of £1,000 per annum, while Mr. Keele allowed no similar charge in his estimate.	NOTE.—The difference, allowing £2,500 for Head Office expenses (for two and a half years) is not greater than may be expected between two engineers estimating for a large work.	47-49
...the estimated cost of work ...uthorised by the Govern- ...nt, on the recommendation ...the Board of Health, as an ...rnative to moving the ...up.	.....	.....	400 0 0	400 0 0	The diversion of the low discharges of the Cataract River, so that they may not flow into Prospect Reservoir.	Dr. Kendall.	65-70
Total	217,509		342,050 10 9	124,550 10 9			
...to Mr. Keele's estimate 10 ...cent., as allowed by the	21,750	Allow credit of 50 per cent. on prime cost of plant.	16,553 12 6				80
Total	239,259		325,496 18 3	86,296 18 3	NOTE. This sum is the nett amount by which the probable cost of the dam exceeds the amount allowed by the Act.		

...the nett amount which, under the Act, he might have expended on his dam. Mr. Keele having stated that he would have required £17,000 worth of plant, ... £15,000, £6,000, £7,500, which would have brought his nett cost down to

XIV. Concluding Remarks.

Acknowledgment of Mr. Simpson's services.

402. Your Commissioner desires to express his obligation to Mr. D. C. Simpson, M.I.C.E., for his very valuable advice and assistance in dealing with the engineering aspect of the questions submitted for the finding of the Commission. Mr. Simpson has attended all the sittings of the Commission, has paid three visits to the dam, and has given very careful attention to the evidence throughout the whole period of the Commission. As already stated, the Railway Commissioners very courteously placed his services at my disposal, and these have been very freely availed of.

Mr. Cardew.

403. All the parties to this Inquiry must have been impressed by the great fairness and impartiality of Mr. Cardew, and by the care and thoroughness with which he discharged his duties as an expert witness for the Commission; and I desire to express my appreciation of the very able and conscientious manner in which he discharged these duties.

Secretary.

404. Mr. Garlick discharged his duties as Secretary with conspicuous ability, all the more conspicuous as much of his time was occupied with very important duties not connected with the Commission.

Counsel for parties.

405. Mr. H. S. Williams, solicitor to the Metropolitan Board of Water Supply and Sewerage, who appeared for Mr. Keele, and Mr. W. Robison, of the Crown Solicitor's Department, who appeared for the Public Works Department, were of great assistance to the Commission. The presentation of their cases was marked by great fairness and ability.

Shorthand-writers.

406. Mr. A. Walker and Mr. W. C. Day, shorthand-writers, performed their onerous duties to my entire satisfaction. Their services were courteously placed at my disposal by Mr. Addison, Registrar of the Arbitration Court, and Mr. Keele, respectively.

I have the honor to be,

Your Excellency's most obedient servant,

(Sgd.) GEO. A. WILSON,

Commissioner.

(Sgd.) J. Garlick,

Secretary.

28th July, 1905.

A7

1933.

LEGISLATIVE ASSEMBLY.

NEW SOUTH WALES.

REPORT

OF THE

ROYAL COMMISSION OF INVESTIGATION

INTO

Certain matters under the Administrative Control of the Metropolitan Board of Water, Sewerage and Drainage.

TOGETHER WITH

LIST OF WITNESSES, APPENDICES, EXHIBITS & PLANS.

Ordered by the Legislative Assembly to be printed, 22 *June,* 1933.

SYDNEY: ALFRED JAMES KENT, I.S.O., GOVERNMENT PRINTER.

1933.

† 920 *30—A

[9s. 6d.]

the tube internally with 1½ inch cement mortar and externally by packing the annular space between the tube and the existing tunnel walls with high class concrete. The cost of removing the tunnel lining in order to introduce a tube of the same size, namely 10 feet diameter, was considered prohibitive, and a certain clearance was necessary between the tube and the tunnel to enable the tube to be handled and to ensure the thorough compacting of the concrete in the annular space. Mr. Haskins decided that the required clearance for those purposes necessitated reducing the size of the tube to 8 ft. 3 in. diameter internally, and in this view he was supported by Mr. Dare and Mr. Ritchie, and, with certain qualifications, by Mr. Mitchell and Mr. Farrow when giving evidence before the Commission. Another feature of the proposal was the introduction of an internal spigot and faucet joint packed with extruded lead.

Mr. Haskins considered that this proposal was the only really reliable one of the alternatives submitted, and as it was also estimated to be the cheapest he recommended its adoption to the Board. This recommendation was also supported by Messrs. Dare and Ritchie.

It has been explained by Mr. Haskins in evidence that the size of the tube was determined solely from the point of view of the practicability of the construction and it was only later, during the carrying out of the design, that it was found that the reduced size would still be large enough to supply the maximum discharge that the tunnel was expected to provide in the future, the work of which does not support Mr. Haskins' statement in this regard, vide Appendix 5.

After letting the contract for the supply of the steel tubing, further attention was directed to the matter of internal lining. Cement lining of the tube was expensive; it could not be carried out at the contractor's works; and the flexibility of the tube involved practical difficulties in handling it when lined without fracture of the lining material. After a considerable amount of experimenting, at the instance of Mr. Haskins, the chemists of the Australian Gas Light Company and the Australian Iron and Steel Company evolved a bituminous mixture, known as 5A, constituted as follows:—

	Per cent.
Coal tar pitch	50
Mexphalte 80-100 penetration	30
Diatomaceous earth	20
	100

This mixture had a ball and ring softening point of 190 degrees Fahr., a penetration of 77 degrees Fahr. of 14, and a strip representing ⅛ of the tube circumference suspended for seven hours in water at a temperature of 150 degrees Fahr. showed a flow at the bottom of the strip of ⅛ inch. This mixture was evolved to meet the following conditions specified by Mr. Haskins, namely, that it should have a maximum thickness of ¼ inch; should be plastic at 50 degrees Fahr.; and should show no tendency to flow at 150 degrees Fah.

The mixture 5A was adopted and lining proceeded in February, 1931. In June, 1931, it was found that one of the linings showed signs of brittleness. On investigation by the chemists it was found that the brittleness was apparently due to some variation in the nature of the Mexphalte used. The Chief Engineer's stipulation with regard to resistance to flow at 150 degrees F. was now somewhat relaxed, and a new mixture named 6C was evolved with the following composition:—

	Per cent.
Coal tar pitch, 20-30 penetration	40
Mexphalte, 40-50 penetration	40
Diatomaceous earth	20
	100

At this point, however, all the work was stopped for the time and the 6C mixture was not used. In all, up to this time, 0.135 miles of pipes lined with the 5A mixture had been placed in position.

The failure of the lining above referred to, had caused the Chief Engineer some concern, and further experimenting was, therefore, undertaken, using residual bitumens without any admixture of coal tar pitch, and finally Mexphalte R2 was adopted with 10 per cent. of diatomaceous earth. This is an air blown residual bitumen with a penetration of 30-40, and it is stated that there is no tendency to run at 160 degrees F. The proportion of diatomaceous earth was determined after a number of trials as being the most satisfactory with this bitumen, and a sample pipe coated with this mixture and left in the open for over a year showed only slight signs of corrugation.

The process of lining is briefly as follows:—The R2 Mexphalte is melted down in ladles and then transferred by crane to the mixer after weighing. The mixing paddles are started and the correct amount of diatomaceous earth added through a ½-inch screen. The routine is continued for two hours at least at a temperature of 350 degrees F. before pouring into the pipe. Before receiving the mixture, the pipe in the spinning machine is mechanically brushed, swept, wiped out, and cleansed while warm. The oil burners now increase the heat of the pipe up to 350 degrees F., the correct heat being ascertained by fusible alloys, and when that temperature has been reached, the bituminous mixture is tipped into the pipe which is revolving at a speed of approximately 400 revolutions per minute. After spinning for one minute, water is sprayed on which reduces its temperature to 100 degree F. in two to five minutes, after which it is removed from the machine.

It is estimated that the substitution of bituminous lining for the cement lining originally contemplated will result in a saving of over £47,000, or nearly 62 per cent. The use of bitumen for lining the pipes, in addition to effecting a saving of cost, also increases the co-efficient of discharge. From evidence furnished it would appear that the co-efficient C used in the Hazen-Williams discharge formulae can be taken as 129 for straight cement lined pipes and 145 or more for bituminous lined pipes, provided there were no internal protruding joints.

There are many historical instances of the use of pitch or bitumen for preserving materials against the action of water, but the application by means of spinning is a modern process which is now being used in England, Ireland, Scotland, United States, South America, South Africa, and China. The process as developed in Sydney has certain peculiarities and patent rights have been applied for.

As already stated, the determining factor in deciding what size of pipe to adopt was the practicability of fixing it in the tunnel and making it secure against external corrosion. Subsequently, calculations were made by the Board's officers to determine the quantity of water that the tunnel would ultimately be called upon to supply, and how far the capacity of the reduced area could meet that demand. The following is a statement of the calculation, etc., submitted by Mr. Haskins in his evidence:—

From an examination of population statistics, the increases in the various districts controlled by the tunnel were estimated, and it was considered that the whole of the area would reach saturation density in 1955 with a population of 1,477,000 people, and the consumption of this population represented, therefore, the maximum that the pressure tunnel and its accessories would have to provide. It was estimated at that date the consumption per capita would be as follows:—

	Gallons.
Average for the year per day	54
Maximum for a day	100
Maximum for one hour of the maximum day	208

Of the total amount supplied nearly 30 per cent. would be pumped from the Waterloo Pumping Station to the various service reservoirs feeding the Eastern Suburbs and would, therefore, not be subjected to hourly fluctuations. The maximum consumption of the population in 1955 would be as follows:—

Maximum day—

	m. gals.
Main area	105.2
Eastern Suburbs	42.5
	147.7

Maximum rate for one hour—

	m.d.g.
Main area	214.5
Eastern Suburbs	42.5
	257.0

To supply this water it is proposed to construct an elevated reservoir at Potts Hill at El. 273 with a capacity of 18 m. gals., and to connect the tunnel at shaft 17 by means of a 6-ft. diameter pipe or tunnel to the existing Centennial Park reservoir, El. 245 and capacity 38 m. gals. The two reservoirs together with the water reaching the Potts Hill elevated reservoir from Pipe-head and from the proposed Woronora and O'Hare's Creek conduits would form a balanced system which would be just sufficient in 1955 for the maximum day's consumption of 147.7 m. gals., or the maximum hourly rate of 257 m.d.g. It was further calculated that building the Potts Hill reservoir 10 feet higher, the maximum day's discharge could be lifted to 180 m. gals., equivalent to the needs of a population of 1,800,000 people. If, in addition, the existing 48-inch main were reconditioned, the extra water that could be provided would be from 24 to 46 m.d.g.* corresponding to another 240,000 to 460,000 people. It was contended, therefore, that the tunnel as now being altered would be fully capable of supplying the needs of a population of up to 2,000,000 people.

With regard to the general question of water supply (Plan 3), it was explained that the proposals contemplated bringing in the water from the Nepean, Avon, and Cordeaux Dams by

* According to whether the pipes discharged under gravity or boosting conditions.

means of the existing canals, and to connect Cataract Dam with the proposed dams at Woronora and O'Hare's Creek which would supply high pressure water to the city in two pipe lines, one feeding Penshurst and the other going to the proposed Potts Hill reservoir. The drafts of these dams would be as follows:—

	Safe draft.	Normal draft.
Nepean	33	45
Avon	33	39
Cordeaux	20	24
Unregulated	10	11
	96	119
Cataract	29	35
O'Hare's Creek	18	20
Woronora	20	23
	67	78

With regard to the aqueducts, it is proposed to increase the capacity of the Nepean tunnel so as to bring the capacity of the upper canal up to 150 m.d.g. throughout, and to build an additional pipe line between Prospect and Pipe-head so as to bring the capacity of the lower canal system up to 240 m.d.g., and by putting an additional head on to the water entering the pipes at Pipe-head to increase the capacity of the conduits to Potts Hill to 176 m.d.g. By making full use of the water stored in Prospect it would be possible to draw off about 225 m.d.g. during the summer months.

The two pipe lines from the Woronora series of dams would have a maximum capacity of 144 m.d.g.

The total amount of water that could be conveyed to the city by all the conduits would be 369 m.d.g., of which approximately 90 m.d.g would go from Pipe-head to the northern suburbs and 69 m.d.g. to Penshurst, leaving approximately 210 m.d.g. available at Potts Hill for the pressure tunnel and the 48-inch pipes.

It was estimated that in 1940 the limit would be reached of the safe drafts from the existing dams and of the capacity of the canal system to deliver the water, and the Woronora-O'Hare's Creek dams and their aqueducts would be required. The plan attached illustrates these proposals, and contains tables of capacities. The estimated figures for 1940 are as follows:—

Estimated average daily demand—121.7 m.d.g.
Draft from Cataract, Nepean, Avon and Cordeaux dams—125 m.d.g. safe; 154 m.d.g. normal.
Estimated maximum daily demand—225.7 m.d.g.
Estimated maximum capacity of conduit system—225 m.d.g.

The Commissioners have not attempted to investigate the correctness of the figures put forward by Mr. Haskins as to the capacities of the various dams and existing or proposed conduits, nor do they offer any comments as to the soundness or otherwise of the schemes for augmenting the water supply (including the proposal for using the Warragamba dam) that have been placed before them by Mr. Haskins. These matters, though interesting, are outside the scope of the inquiry that the Commissioners have been directed to make. An examination, however, has been made of the estimates of the future consumption in the area controlled by the pressure tunnel and of the maximum capacity of the tunnel and its accessories.

The last phase of the evidence offered by Mr. Haskins concerned the manner in which he anticipated that the full use of the tunnel would be developed. He divided this development into five stages as follow:—

Stage 1.

Conditions as at present pending the completion of the pressure tunnel which is at present insufficient to meet the maximum summer demand as evidenced by the deficiency of suction water at Crown-street and Waterloo Pumping Stations, and by the inadequate pressures and local failures of supply at the extremities of boosted areas. The actual pumping cost per annum is at present about £75,000, which is expected to increase to £87,000 by 1935.

Stage 2.

The pressure tunnel placed in commission and acting under gravity from the existing Potts Hill reservoir at El. 178, the area outside the gravitation zone being supplied by pumped water from Potts Hill through existing pipes and from Waterloo. The pumping costs for existing consumption would be reduced under these conditions from £75,000 to £66,000 per annum.

The two 48-inch mains now supplying Crown-street would be placed out of commission for the purpose of reconditioning them.

Stage 3.

The reconditioned 48-inch mains would be put back into commission, operating under gravity from the Potts Hill reservoir to supply a considerable area of the southern suburbs. The Potts Hill pumping station would deliver all water into the pressure tunnel under a boosted head of 110 feet. The Waterloo pumping station and that of Crown-street would operate as before, but under an increased suction head.

The pumping costs on the basis of present consumption would be reduced to £58,000.

Stage 4.

The proposed elevated reservoir at Potts Hill (El. 273) having been constructed, the pressure tunnel would be connected thereto, and to the Centennial Park reservoir. The zoning would be similar to that in Stage 3, with the exception that the Centennial Park zone would be fed direct from the pressure tunnel. The pumping costs on the basis of present consumption would be still further reduced to £53,000 per annum.

Stage 5.

The high pressure conduits from the Woronora-O'Hare's Creek system of dams would now be available—that from Woronora going direct to Penshurst, and that from O'Hare's Creek feeding the Potts Hill elevated reservoir. Pumping in this stage would be restricted to that at Potts Hill, which is required to make good any deficiencies of the high pressure water deliveries into Potts Hill elevated reservoir, and that at Waterloo as in Stage 4. Pumping costs would be reduced to £21,000 per annum.

APPENDIX 2.

PRESSURE TUNNEL: THEORY OF DESIGN.

In order to intelligently investigate the cause or causes of the failure it is necessary to form a working theory of design. The available literature on the subject includes a few empirical rules, but there is little that can be regarded as forming the basis of a theory.

The Commission, after examining all the available facts, have developed the following working theory based on four hypotheses, which are illustrated by the particulars of the failure of the Potts Hill pressure tunnel near shaft 7. At this point the sandstone cover over the tunnel is about 20 feet, followed by 100 feet of shale, and 20 feet of clay and soil—a total cover of 150 feet. The tunnel is 10 feet internal diameter with a 2-foot average thickness of lining. The level of the ground water has been assumed as 75 feet below the surface or 109 feet above the centre line of the tunnel. The maximum internal hydrostatic pressure is taken as that due to Cecil Hill, which is 266 above datum or 375 feet above the centre line of the tunnel and is equivalent to 163 lb. per square inch. The actual test heads were 100 feet, 180 feet, 280 feet, and 430 feet measured presumably to the invert level.

The problem is investigated under four hypotheses which are illustrated in Plan 4.

FIRST HYPOTHESIS.

Tunnel lining remains intact and impervious.

Surrounding rock solid and not subject to local fractures.

The forces in operation would then consist of—

(1) The internal hydrostatic pressure on 10-foot dia.
(2) The external hydrostatic pressure derived from the ground water and acting on 14-foot external dia. lining.
(3) The weight of the rock above the tunnel (reduced where it is immersed in the ground water).
(4) The further resistance of the rock to rupture due to its shearing, compressive and transverse strengths.

If the tunnel remains intact, items (2), (3), and (4) must together be equal to or greater than item (1).

The two hydrostatic pressures (items 1 and 2) are opposed to each other and by deducting 2 from 1 the unbalanced hydrostatic head operating on the tunnel lining per foot run of the tunnel would be about 150,000 lb.

The resistance of the rock to rupture might be taken as that of a wedge of rock with a bottom width of 10 feet and sides diverging at an angle of at least 30 degrees from the vertical. The resistance of such a wedge is provided by the weight of the rock (making allowance for the portion submerged below the water-table) which is a function of the square of its height, and also by the shearing strength of the rock along the two sides of the wedge, which is a function of the height. The net weight of the rock per foot run of the tunnel amounts to 2,400,000 lb. approximately, and adopting an average shear value for the sandstone and shale of 100 lb. per square inch, the shearing resistance on the two sides of the wedge would be approximately 6,000,000 lb. The combined resistance, therefore, to the unbalanced hydrostatic pressure of 150,000 lb. would be 8,400,000 lb., giving a factor of safety of 56.

The tunnel, therefore, on this hypothesis would have an ample margin of safety.

SYDNEY WATER SUPPLY

STORAGE & AQUEDUCT SYSTEMS

Proposed Future Development

Scale 0 8 Miles

Lower Canal	93 M.d.g.
54" W.S. Main	50 "
	143 M.d.g.
72" Main & Improvement to Lower Canal	97 M.d.g.
	240 M.d.g.

3-72" Mains	81 M.d.g
46" W.S. Main	15 "
	96 M.d.g.
Application of Additional Hd.	80 M.d.g.
	176 M.d.g.

PRESSURE TUNNEL CAPACITIES

			M.d.g.
Under Gravitation Hd R.L.175' and with Total Hd. loss to Shaft 17 of 20 Ft.			97
Under Boosted Head R.L.273' and Residual Hd at Shaft 17 R.L. 200 Ft.			195
Under Elev. Res. Hd. R.L.273 Centennial Res acting as Balance Storage.			
do. do.	Residual Hd at lowest point on Hydraulic Gradient	R.L.232	257
do. do.	Assumed residual Hd at lowest Pt on Hyd Gradient	R.L.217	305
do. do.	do.	do. 222	348
do. do.	do.	do. 217	382
do. do.	do.	do. 215	400

No 1 & 2 - 48" Mains	Cap. Boosted	46 M.d.g
	Cap. Under Gravity Hd.	25 M.d.g

By Expenditure of £100,000 in Reconditioning Asset Value of £600,000 will be Preserved.
Cost to Renew £1,000,000

SCHEDULE	ESTIMATED COST £
1 Completion of Nepean Dam to Storage Point	200,000
2 Nepean - Avon Tunnel Connection	75,000
3 Raising Pheasants Nest Weir	100,000
4 Local Storages - Liverpool & Ingleburn	26,000
5 72" Main - Upper Canal to Pipe Head	300,000
6 Syphon Outlets from Prospect; Improvements to Lower Canal and Low Lift Pumps	50,000
7 Alterations & Additions to Potts Hill Pumping Plant	69,500
8 Completion of Pressure Tunnel Shaft 6-17	558,000
9 Reconditioning of No 1 & 2 48" Mains	100,000
10 Pressure Tunnel Offtake Connections	230,000
11 Completion of Woronora Dam	1,190,860
12 Completion of Woronora-Penshurst Pipe Line	514,000
13 Cataract-O'Hares Ck. Tunnel	141,000
14 O'Hares Ck. Provisional Tunnel	85,000
15 O'Hares Ck. Woronora Tunnel	100,000
16 Pipe Line - O'Hares Ck. Woronora Tunnel Inlet to Potts Hill	1,400,000
17 Penshurst L.L. Service Reservoir	110,000
18 Potts Hill Elevated Reservoir	360,000
19 Connection to Pressure Tunnel Shaft 1	45,000
20 72" Main Connection Shaft 17 to Centennial Pk. Res.	165,000
21 Warragamba Dam & Treatment Plant	2,756,000
22 Warragamba Aqueduct (Single Aqueduct) (As per Report of Special Committee)	3,750,000

Duplicate Aqueduct as provided for by Special Committee

WARRAGAMBA AQUEDUCT Cap. 200 M.d.g (Max. Demand Contour) Local Storage Impounding with Cap. of Pipe Lines 168 M.d.g as a Compensating Supply with average of 180 M.d.g

WARRAGAMBA DAM Drawoff Level R.L. 240'

Catchment Safe Draft 3,383 Sq. Miles 225 M.d.g. (25 M.d.g. Compensation Water)

Pheasants Nest & Diversion Weir Crest of Weir R.L. 439·5' Raising of Weir to Increase Tunnel Capacity

Broughton Pass R.L. 430

Completion of Nepean Dam Safe Draft 33 M.d.g. Normal " 45 "

Nepean-Avon Tunnel

Avon Dam S.D. 33 M.d.g N.D. 39 "

Cordeaux Dam S.D. 20 M.d.g N.D. 24 "

Catchment 118 Sq Miles Safe Draft 67 M.d.g. Normal Reg. Output 78 M.d.g.

Catchment 347 Sq. Mls. Safe Draft 125 M.d.g. (96 M.d.g. ex Cataract) Normal Reg. Output 154 M.d.g. (19 ex Cataract)

Cataract Dam S.D. 29 M.d.g N.D. 35 "

Temporary Tunnel (Unlined) pending Construction of O'Hares Ck. Dam

O'Hare's Creek Dam S.D. 16 M.d.g N.D. 20 " R.L. 700

Tunnel Outlet R.L. 675'

Woronora Dam Lowest Drawoff Level R.L. 472' S.D. 20 M.d.g N.D. 23 "

Penshurst R.L. 240

Potts Hill Reservoir R.L. 175'

Potts Hill Elev. Reservoir R.L. 273'

Prospect Reservoir R.L. 196·7 Balance Storage Available to R.L. 190' 2,200 M.G.

Lower Canal Cap. 93 M.d.g

72" Main Cap. 50 M.d.g

54" W.S. Main Cap. 20 M.d.g

46" W.S. Main Cap. 15 M.d.g

Syphon Outlets

Pipe Head

36" & 48" Duplicate

48" Mains

Low Lift Pumps

No 1 & 2 48" Mains

Pressure Tunnel

Ryde P.S.

Waterloo P.S.

Centennial Reservoir R.L. 245' Capacity 38 M.G.

Botany Bay

Ocean

Pacific

Lake Illawarra

Year to June	Anticipated Average Daily Demand	Corresponding Max. Daily Demand N & S. Divisions	N. Division	S. Division
	M.D.G.	M.G.	M.G.	M.G.
1932	86·04	164·9	34·5	130·4
1933	89·86	171·5	36·0	135·5
1934	93·87	178·4	37·7	140·7
1935	98·02	185·5	39·4	146·1
1936	102·40	193·0	41·2	151·8
1937	106·93	200·7	43·1	157·6
1938	111·65	208·7	45·1	163·6
1939	116·63	217·1	47·3	169·8
1940	121·74	225·7	49·5	176·2
1941	127·00	234·8	52·0	182·8
1942	132·50	244·2	54·5	189·7
1943	138·50	254·0	57·1	196·9
1944	144·50	264·1	60·0	204·1

Cost of Water (per 1000 Gals) Delivered to Potts Hill Elevated & Penshurst Reservoirs.

Source of Supply		Estimated or Actual Expenditure Head of Works & Aqueducts	Supply in M.d.g.	Cost per 1000 gals. delivered to Potts Hill Devt Res.	Cost per 1000 gals. delivered to Penshurst Reservoir	Total Annual Maintenance	Cost per 1000 for Maintenance	Total Cost per 1000 Gls. including Interest, Pumping & Maintenance Delivd to Potts Hill	Delivd to Penshurst
Existing Catchments	Cataract Cordeaux Avon Nepean	£8,406,406	125(S.D)	2·6 pence	3·4 pence	£33,000	0·17 pence	2·77 pence	3·57 pence
Existing Catchments	Cordeaux Avon Nepean	£7,981,604 0,106,604	86(S.D) 119(N.D)	3·30 pence 2·65 "	4·05 pence	£31,300	0·21 pence 0·17 "	3·51 pence 2·82 "	4·36 pence
	Cataract O'Hares Ck. Woronora	£5,857,423	67 (S.D) 78 (N.D.)	2·7 pence 2·8 pence		£7,000	0·07 pence 0·06 "	2·77 pence 2·86 "	
Warragamba (Safe Draft 200 M.d.g)		£6,506,000	20 M.d.g. 40 " 67 " 78 "	10·8 pence 5·4 " 3·4 " 3·0 "	11·0 pence 6·2 " 4·1 " 3·75 "	Taken as ½% of Capital Cost £32,500	1·05 pence 0·53 " 0·32 " 0·27 "	11·35 pence 6·85 " 3·72 " 3·27 "	12·05 pence 6·73 " 4·42 " 4·02 "

G Haskins

M. Inst. C.E.

10-1-38

Chief Engineer

A.M.C. 10.1.38.

APPENDIX B:

Description		Reference
Register of Large Dams in Australia 1990		1
ICOLD World Register of Dams 1973	Germany Australia United States Great Britain Peru	2
ICOLD Word Register of Dams 1988	South Africa	3

B1

Register of Large Dams in Australia

April 1990

International Commission on Large Dams
Australian National Committee on Large Dams

LINE No	NAME OF DAM	Year of completion	SITUATION			TYPE	Position and nature of sealing	FOUND.	Height above lowest foundation (m)	Length of crest (m)	Volume content of dam (10^3m^3)	Capacity of reservoir (10^3m^3) / Reservoir area (10^3m^2)	PURPOSE	Maximum discharge capacity of spillways (10^3m^3)	Type of spillways	OWNER	ENGINEERED BY	CONSTRUCTION BY	LINE No
			River	Nearest city	State														
1	MANLY	1892	CURL CURL CREEK	SYDNEY	NSW	PG			20	256	8	2000 372	R, C	210	L	WATER BOARD SYDNEY	DEPARTMENT OF PUBLIC WORKS, NSW	DEPARTMENT OF PUBLIC WORKS, NSW	1
2	STEPHENS CREEK	1892	STEPHENS CREEK	BROKEN HILL	NSW	TE	he	R	18	256	72	24325 8500	S	91	L	BROKEN HILL WATER BOARD	BROKEN HILL WATER SUPPLY Co	BROKEN HILL WATER SUPPLY Co	2
3	CLARENDON WEIR	1896	ONKAPARINGA	ADELAIDE	SA	PG			15	81	47	330 85	S	1031	L	STH AUST GOVERNMENT ENG & WATER SUPPLY DEPARTMENT	STH AUST GOVERNMENT ENG & WATER SUPPLY DEPARTMENT	J WISHART & SON & STH AUST GOVT ENG & WATER SUPPLY DPT	3
4	HAPPY VALLEY	1896	OFFSTREAM	ADELAIDE	SA	TE	le	R/S	34	806	547	15060 1930	S		L	STH AUST GOVERNMENT ENG & WATER SUPPLY DEPARTMENT	STH AUST GOVERNMENT ENG & WATER SUPPLY DEPARTMENT	STH AUST GOVERNMENT ENG & WATER SUPPLY DEPARTMENT	4
5	KORUMBURRA No 1	1896	COALITION CREEK	KORUMBURRA	VIC	TE	lc	R	15	208		204 46	S		L	KORUMBURRA WATERWORKS TRUST			5
6	JUNCTION REEFS	1897	BELLUBULA	MANDURAMA	NSW	MV			19	10(	15	7300	H			LYNDHURST GOLDFIELDS COY LTD	LYNDHURST GOLDFIELDS COY LTD	LYNDHURST GOLDFIELDS COY LTD	6
7	MOORES CREEK	1898	MOORES CREEK	TAMWORTH	NSW	VA			19	155		220	S	250	L	TAMWORTH CITY COUNCIL	DEPARTMENT OF PUBLIC WORKS NSW	DEPARTMENT OF PUBLIC WORKS NSW	7
8	NECTAR BROOK	1899	NECTAR BROOK	PT AUGUSTA	SA	TE	le	R/S	24	464	158	700 117	S	480	L	STH AUST GOVERNMENT ENG & WATER SUPPLY DEPARTMENT	STH AUST GOVERNMENT ENG & WATER SUPPLY DEPARTMENT	STH AUST GOVERNMENT ENG & WATER SUPPLY DEPARTMENT	8
9	REDBANK CREEK	1899	REDBANK CREEK	MUDGEE	NSW	VA			16	152	5	180 30	S	35	L	MUDGEE COUNCIL	DEPARTMENT OF PUBLIC WORKS NSW	DEPARTMENT OF PUBLIC WORKS NSW	9
10	BAROSSA	1902	OFFSTREAM	ADELAIDE	SA	VA			36	280	14	4515 620	S		L	STH AUST GOVERNMENT ENG & WATER SUPPLY DEPARTMENT	STH AUST GOVERNMENT ENG & WATER SUPPLY DEPARTMENT	STH AUST GOVERNMENT ENG & WATER SUPPLY DEPARTMENT	10
11	BUNDALEER	1902	OFFSTREAM	PT PIRIE	SA	TE	le	R/S	38	334	292	6370 800	S	24	L	STH AUST GOVERNMENT ENG & WATER SUPPLY DEPARTMENT	STH AUST GOVERNMENT ENG & WATER SUPPLY DEPARTMENT	STH AUST GOVERNMENT ENG & WATER SUPPLY DEPARTMENT	11
12	MUNDARING	1902	HELENA	PERTH WA	PG				71	308	124	76390 7610	S	1019	V	WATER AUTHORITY OF WA	PUBLIC WORKS DEPT, WA	PUBLIC WORKS DEPT, WA	12
13	MT COLE	1903	SPRING CREEK	ARARAT	VIC	VA			28	132		800 120	S	36	L	ARABAT CITY COUNCIL COMMISSION	BA & DB SMITH		13
14	UPPER COLIBAN	1903	COLIBAN	KYNETON	VIC	TE	le	S	28	407	182	31500 3400	I, S	283	L	RURAL WATER COMMISSION VIC			14
15	PEKINA	1905	PEKINA CREEK	PT PIRIE	SA	TE	le	R/S	24	146	72	600 233	I	795	L	STH AUST GOVERNMENT DEPARTMENT OF LANDS	STH AUST GOVERNMENT ENG & WATER SUPPLY DEPARTMENT	STH AUST GOVERNMENT ENG & WATER SUPPLY DEPARTMENT	15
16	WARANGA Waranga Basin (res)	1905	OFFSTREAM	TATURA	VIC	TE	he	S	12	7001		411000 58480	I			RURAL WATER COMMISSION VIC	SRWSC	SRWSC	16
17	FROME	1906	FROME	LAUNCESTON	TAS	ER	fc	R	18	183		2	H	80	L	BMI MINING PTY LTD			17
18	CATARACT	1907	CATARACT	CAMPBELLTOWN	NSW	PG			56	247	113	94300 8510	S	1600	L	WATER BOARD SYDNEY	DEPARTMENT OF PUBLIC WORKS, NSW	DEPARTMENT OF PUBLIC WORKS NSW	18
19	LAKE MEDLOW	1907	ADAMS CREEK	KATOOMBA	NSW	VA			20	53	1	300 60	S	15	L	WATER BOARD SYDNEY	DEPARTMENT OF PUBLIC WORKS, NSW	DEPARTMENT OF PUBLIC WORKS NSW	19
20	LITHGOW No 2	1907	FARMER'S	LITHGOW	NSW	VA			27	70	5	440	S	30	L	LITHGOW CITY COUNCIL	DEPARTMENT OF PUBLIC WORKS, NSW	F.J. CARSON	20
21	CASCADE No 1	1908	CASCADE CREEK	KATOOMBA	NSW	VA			17	112	4	160 28	S	4	L	WATER BOARD SYDNEY	DEPARTMENT OF PUBLIC WORKS, NSW	GILMORE & CONNELL	21
22	KORWEINGUBOORA	1910	E MOORABOOL	BALLAN	VIC	TE ER	le/c	R/S	12	623	84	2091 610	S	190	L	GEELONG WATERWORKS & SEWERAGE TRUST	VICTORIA WATER SUPPLY DEPT	ALEXANDER LYNCH	22
23																			23
24	LANCE CREEK	1911	LANCE CREEK	WONTHAGGI	VIC	TE	lc	R/S	21	480	86	4600 820	S	73	L	RURAL WATER COMMISSION VIC	J & H COANE	J & H COANE	24
25	PYKES CREEK	1911	PYKES & MYERS	BALLAN CREEKS	VIC	TE	le	S	39	443		24000 2030	I, S	292	L	RURAL WATER COMMISSION VIC COMMISSION, VICTORIA	STATE RIVERS & WATER SUPPLY	STATE RIVERS & WATER SUPPLY COMMISSION, VICTORIA	25

1 RAISED 0.5 m IN 1909, 0.5 m IN 1914, 6 m IN 1922, POST TENSIONED 1981
2 RAISED 1 m IN 1909
5 RAISED 1924
6 DATE APPROXIMATE
12 RAISED 1951
13 RAISED 1926, 5.2 m, RAISED 4 m BY KINHILL, 1986
14 BANK RAISED 1917, 1925 SIPHONIC SPILLWAY ADDED
15 SILTATION HAS REDUCED CAPACITY FROM 1540 TO 600
18 SPILLWAY MODIDIED 1983, DAM WALL POST TENSIONED 1988
20 RAISED 2 m IN 1925, SPILLWAY MODIFIED 1983, DAM BEING POST TENSIONED
21 RAISED 1915
23 RAISED 1915, COREWALL ADDED 1926
24 RAISED 4 m IN 1986, VOLUME CONTENT REFERS TO ENLARGEMENT ONLY
25 RAISED 1930

B2

INTERNATIONAL COMMISSION ON LARGE DAMS
COMMISSION INTERNATIONALE DES GRANDS BARRAGES

WORLD REGISTER OF DAMS

REGISTRE MONDIAL DES BARRAGES

1973

REGISTRE DES BARRAGES EN AFRIQUE DU SUD
REGISTER OF DAMS IN REPUBLIC OF SOUTH AFRICA

FOLIO No. 1

1 LIGNE / LINE No	2 NOM DU BARRAGE / NAME OF DAM	3 ANNEE D'ACHEVEMENT / YEAR OF COMPLETION	4 SITUATION LOCATION: COURS D'EAU / RIVER	5 SITUATION: VILLE LA PLUS PROCHE / NEAREST CITY	6 SITUATION: ETAT PROVINCE OU DEPARTEMENT / STATE PROVINCE OR COUNTY	7 TYPE	8 HAUTEUR AU DESSUS DE LA PLUS BASSE FONDATION / HEIGHT ABOVE LOWEST FOUNDATION (m)	9 LONGUEUR DE CRÊTE / LENGTH OF CREST (m)	10 VOLUME DU BARRAGE / VOLUME CONTENT OF DAM (10³ m³)	11 CAPACITE TOTALE DU RESERVOIR / GROSS CAPACITY OF RESERVOIR (10³ m³)	12 DESTINATION / PURPOSE	13 CAPACITE MAXIMALE DES EVACUATEURS / MAXIMUM DISCHARGE CAPACITY OF SPILLWAYS (m³/s)	14 TYPE DES EVACUATEURS / TYPE OF SPILLWAYS	15 PROPRIETAIRE / OWNER	16 BUREAU D'ETUDES / ENGINEERING BY	17 CONSTRUCTEUR / CONSTRUCTION BY	18 LIGNE / LINE No
1	WOODHEAD	1897	Disa	Cape Town	Cape Province	PG	43	248	19	927	S	28	L	Municipality Cape Town	Thos. Stewart	J. Delbridge & Muncy. of Cape Town	1
2	HELY HUTCHINSON	1904	Disa	Cape Town	Cape Province	PG	16	532	8	914	S	24	L	Municipality Cape Town	Thos. Stewart	J. Delbridge	2
3	ROODE POORT	1904	Lower Krom	Dewets-dorp	Orange Free State	TE	14	94	24	3 530	I	155		Department Education			3
4	SAND RIVER PALMIET	1905	Sand	Uiten-hage	Cape Province	PG X	21	160	33	5 768	S	155	L	Municipality Port Elizabeth	L. Ingham	Municipality Port Elizabeth	4
5	BULK RIVER	1907	Bulk	Uiten-hage	Cape Province	VA	26	203	14	817	S	85	L	Municipality Port Elizabeth	L. Ingham	Municipality Port Elizabeth	5
6	BONGOLA	1908	Bongola	Queens-town	Cape Province	PG X	23	118	14	6 943	S	241	Siphon	Municipality Queenstown	Gellatly 1908 George A. Stewart (1934)	Roberts Construction(1934)	6
7	DE VILLIERS	1910	Disa	Cape Town	Cape Province	PG	30	126	6	243	S	6	L	Municipality Cape Town	Thos. Stewart	J. Delbridge	7
8	HELLSGATE	1910	Klip	Uitenhage	Cape Province	VA	26	4	1	120	-	116	L	Mr. G.V. Naude	L. Ingham	R.H. Heugh	8
9	SMARTT	1912	Ongers-Brak	Brits-town	Cape Province	PG/TE X	28	2 082	387	96 597	I	1 420	L	Department of Water Affairs	Department of Water Affairs	Department of Water Affairs	9
10	LOXTON	1913	Soutpoort	Loxton	Cape Province	TE	17	199	72	1 170	I-S	218	L	Municipality Loxton	Department of Water Affairs		10
11	CALITZDORP	1917	Nels	Calitz-	Cape Province	PG/TE	34	207	46	5 804	I-S	340	L	Irrigation Board	Department of Water Affairs	Department of Water Affairs	11
12	PRINS RIVER	1917	Prins	Ladismith	Cape Province	ER X	34	61	45	4 600	I	420	L	Irrigation Board	Department of Water Affairs	Department of Water Affairs	12
13	BAKER	1918	Laughing Water Spruit	Willow-more	Cape Province	VA	17	168	6	406	S	120	L	South African Railways			13
14	UMZOMIANA	1918	Buffalo	East London	Cape Province	TE	27	543	229	1 222	R	632	L	Municipality of East London	Municipality of East London		14
15	BELLAIR	1920	Brak	Barrydale	Cape Province	TE	20	198	151	12 205	I	110	L	Department of Water Affairs	Department of Water Affairs	Department of Water Affairs	15
16	BETHULIE	1921	Bethulie Spruit	Bethulie	Orange Free State	VA	23	134	11	6 717	S	370	L	Municipality Bethulie			16
17	STEENBRAS	1921	Steenbras	Strand	Cape Province	PG X	36	412	51	32 240	S	481	I	Municipality Cape Town	F.E. Kanthack	Cementation Co. Ltd.	17
18	STOLTZ RIVER	1921	Stoltz	Beaufort West	Cape Province	TE	16	274	97	1 580	I	220	L	Irrigation Board	Department of Water Affairs	Department of Water Affairs	18
19	VICTORIA WEST	1921	Gr.Kruis	Victoria West	Cape Province	VA	25	133		4 099	-	103	I	Municipality of Victoria West	Gellatly		19
20	LAKE MENTZ	1922	Sundays	Jansen-ville	Cape Province	PG X	48	418	209	25 189	I	3 120	V	Irrigation Board	Department of Water Affairs	Department of Water Affairs	20
21	LOWER GOMPIES	1922	Gompies	Potgieters-rus	Transvaal	PG/TE	23	610	57	9 594	I	1 600	L	Zebediela Estates	George A. Stewart and W. Ingham	Owner Built - ebediela Estates	21
22	TYGERPOORT	1922	Kaffir	Bloemfon-tein	Orange Free State	TE	20	116	48	40 503	I	590	L	Irrigation Board	Department of Water Affairs	Department of Water Affairs	22
23	BLYDE	1923	Blyde	Somerset East	Cape Province	TE X	18	341	113	2 428	I	380	L	Irrigation Board	Department of Water Affairs	Department of Water Affairs	23
24	KAMANASSIE	1923	Kamanassie	Oudtshoorn	Cape Province	PG	41	389	107	39 526	I	2 830	L	Irrigation Board	Department of Water Affairs	Department of Water Affairs	24
25	GRASSRIDGE	1924	Groot Brak	Hofmeyer	Cape Province	TE X	24	472	390	86 284	I	1 250	I	Irrigation Board	Department of Water Affairs	Department of Water Affairs	25

NOTES / FOOTNOTES

(4) SAND RIVER PALMIET: RAISED 7.6 m IN 1929

(6) BONGOLA: RAISED 1.2m AND FITTED WITH DOUBLE SIPHONIC SPILLWAY IN 1934

(9) SMARTT: RAISED 9m IN 1950, 2m IN 1946, [illegible] IN 1954

(12) PRINS RIVER: RAISED 2.8m IN 1962

(13) BAKER: RAISED IN 1961

(17) STEENBRAS: RAISED 6 min 1924, 11.5m IN 1927, 1.35m IN 1954, .6m IN 1957

(20) LAKE MENTZ: RAISED 1.5m IN 1935 AND 5.8 m IN 1951

(23) BLYDE: RAISED IN 1962

(25) GRASSRIDGE: RAISED 9m IN 1948

PAYS / COUNTRY: REPUBLIC OF SOUTH AFRICA — AFRIQUE DU SUD

FOLIO No.1

Folio No 1

REGISTRE DES BARRAGES EN ALLEMAGNE (Rép. Féd.)

REGISTER OF DAMS IN GERMANY (Fed. Rep.)

FOLIO No. 1

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
LIGNE *LINE* No	NOM DU BARRAGE *NAME OF DAM*	ANNEE D'ACHEVEMENT *YEAR OF COMPLETION*	SITUATION *LOCATION* COURS D'EAU *RIVER*	VILLE LA PLUS PROCHE *NEAREST CITY*	ETAT PROVINCE OU DEPARTEMENT *STATE PROVINCE OR COUNTY*	TYPE	HAUTEUR AU DESSUS DE LA PLUS BASSE FONDATION *HEIGHT ABOVE LOWEST FOUNDATION* (m)	LONGUEUR DE CRÊTE *LENGTH OF CREST* (m)	VOLUME DU BARRAGE *VOLUME CONTENT OF DAM* (10^3 m^3)	CAPACITE TOTALE DU RESERVOIR *GROSS CAPACITY OF RESERVOIR* (10^3 m^3)	DESTINATION *PURPOSE*	CAPACITE MAXIMALE DES EVACUATEURS *MAXIMUM DISCHARGE CAPACITY OF SPILLWAYS* (m^3/s)	TYPE DES EVACUATEURS *TYPE OF SPILLWAYS*	PROPRIETAIRE *OWNER*	BUREAU D'ETUDES *ENGINEERING BY*	CONSTRUCTEUR *CONSTRUCTION BY*
1	Oderteich	1721	Oder	St. Andreasberg	NS	TE	22	151		1668	S		L	Land Niedersachsen, Forstverwaltung	ne pas connu	ne pas connu
2	Eschbach	1891	Eschbach	Wuppertal	NRW	PG	23	160	17	1100	S,R	9,0	L	Stadt Remscheid	Prof. Intze	Wolf & Vering Düsseldorf
3	Panzer	1893	Panzerbach	Wuppertal	NRW	PG	15	164	2,8	300	S	5,0	L	Stadt Remscheid	Prof. Intze	Albert Schmidt, Lennep
4	Fuelbecke	1897	Fuelbecke	Lüdenscheid	NRW	PG	27	145	18	700	S		L	Fuelbecke-Talsperren Genossenschaft	Prof. Intze	Wilhelm Feldmann, Lüdenscheid
5	Heilenbecke	1896	Heilenbecke	Gevelsberg	NRW	PG	19,5	162	9	450	S	12,0	L	Heilenbecke-Genossenschaft	Prof. Intze	Schütte, Barmen
6	Lingese	1899	Lingesebach	Wuppertal	NRW	PG	26	183	39	2600	C,S,R	22,0	L	Wupperverband	Prof. Intze	Schütte, Barmen
7	Salbach	1899	Salbach	Wuppertal	NRW	PG	25	180	18,2	300	S	5,0	L	Stadt Wuppertal	Prof. Intze	H.E. Lange, Ronsdorf
8	Obere Herbringhauser	1900	Herbringhauser B.	Wuppertal	NRW	PG	34	205	41,9	2900	S	12,0	L	Stadt Wuppertal	Prof. Intze	A. Rothstein & Rose, Beyenburg
9	Sengbach	1902	Sengbach	Wuppertal	NRW	PG	43	178	65	2900	S	23,0	L	Stadt Solingen	Prof. Intze	C. Vering, Hamburg
10	Ennepe	1904	Ennepe	Gevelsberg	NRW	PG	50,5	330	106	12600	S	54,0	L	Ennepe-Wasser-Genossenschaft	Prof. Intze und Raddatz	Dies & Co., Düsseldorf
11	Fürwigge	1904	Verse	Lüdenscheid	NRW	PG	29,1	166	25	1650	S	10,6	L	Ruhrtalsperrenverein	Prof. Intze	Schütte, Barmen
12	Glör	1904	Glör	Lüdenscheid	NRW	PG	32,0	168	35	2100	S			Volme-Wassergenossenschaft	Prof. Intze und Bock	Hermann Dewitz, Max Küster
13	Hasperbach	1904	Hasperbach	Ennepetal	NRW	PG	33,7	260	57	2050	S			Stadt Hagen	Prof. Intze	Chr. Henninger, Bochum
14	Urft	1905	Urft	Schleiden	NRW	PG	58	226	135	45500	C,H,S	400,0	L	Talsperrenverband Eifel-Rur (TVER)	Talsperrenverband Eifel-Rur (TVER)	Philipp Holzmann & Co., Frankfurt/Main
15	Jubach	1906	Jubach	Lüdenscheid	NRW	PG	27,7	152	28	1050	S			Volme-Wasserverband	Prof. Intze und Bock	Hermann Dewitz und Max Küster
16	Oester	1906	Oester	Plettenberg	NRW	PG	36	231	52	3100	S			Oester-Wasser-Genossenschaft	Prof. Intze und Link	Schütte, Barmen
17	Neye	1909	Neyebach	Wuppertal	NRW	PG	31	260	55,2	6000	S	27,0	L	Stadt Remscheid	Prof. Intze	Ernst Jüngst, Hagen
18	Dreiländerbach	1912	Dreiländerbach	Monschau	NRW	PG	37	240	85	4280	S	21,0	V	Wasserwerk des Landkreises Aachen	Wasserwerk des Landkreises Aachen	Diff & Co., Düsseldorf
19	Kerspe	1912	Kerspebach	Wuppertal	NRW	PG	34	360	70	15500	S	28,0	L	Stadt Wuppertal	Prof. Intze	Dyckerhoff & Widmann Biebrich/Rhein
20	Lister	1912	Lister	Olpe	NRW	PG	40	264	111	22000	S	91,8	L	Ruhrtalsperrenverein	Link	Arno Möller, Mannheim
21	Brucher	1913	Brucherbach	Wuppertal	NRW	PG	28	200	28	3300	C,S,R	11,0	L	Wupperverband	Prof. Intze	Peter Büscher & Sohn Münster
22	Drohn	1913	Drohn/Mosel	Trier	RPf	PG	22	95	9	500	H	135,0	L	Moselkraftwerke Andernach		
23	Möhne	1913	Möhne	Neheim/Rüsten	NRW	PG	40,3	650	267	134500	S	241,0	L	Ruhrtalsperrenverein	Ruhrtalsperrenverein	Lissenhoff, Dortmund
24	Saalach	1913	Saalach	Bad Reichenhall	B	PG	14,0	38,0	5,3	3500	H	800,0	V	Deutsche Bundesbahn	Abteilg. f. Wasserkraftausnutzg. im Bayer. Staatsmin. Früh. Pr. Wbv. Weserstrombauverwaltg., Hannover	Liebold & Cie., Langebrück
25	Eder	1914	Eder	Bad Wildungen	H	PG	48	399	300	202400	N,S,H,R	250,0	L	Wasser-und Schiffahrtsverwaltung		Philipp Holzmann, Frankfurt/Main

NOTES
FOOTNOTES

Folio No 1

ALLEMA... (Rép. F...
GERMA... (Fed. R...
COUNTRY

REGISTER OF DAMS IN GERMANY (Fed. Rep.)

2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
NOM DU BARRAGE *NAME OF DAM*	ANNEE D'ACHEVEMENT *YEAR OF COMPLETION*	SITUATION *LOCATION* — COURS D'EAU *RIVER*	VILLE LA PLUS PROCHE *NEAREST CITY*	ETAT PROVINCE OU DEPARTEMENT *STATE PROVINCE OR COUNTY*	TYPE	HAUTEUR AU DESSUS DE LA PLUS BASSE FONDATION *HEIGHT ABOVE LOWEST FOUNDATION* (m)	LONGUEUR DE CRÊTE *LENGTH OF CREST* (m)	VOLUME DU BARRAGE *VOLUME CONTENT OF DAM* (10^3 m^3)	CAPACITÉ TOTALE DU RESERVOIR *GROSS CAPACITY OF RESERVOIR* (10^6 m^3)	DESTINATION *PURPOSE*	CAPACITÉ MAXIMALE DES EVACUATEURS *MAXIMUM DISCHARGE CAPACITY OF SPILLWAYS* (m^3/s)	TYPE DES EVACUATEURS *TYPE OF SPILLWAYS*	PROPRIÉTAIRE *OWNER*	BUREAU D'ETUDES *ENGINEERING BY*	CONSTRUCTEUR *CONSTRUCTION BY*	LIGNE *LINE* No
Diemel	1924	Diemel	Niedermarsberg	NRW	PG	42,0	194	72	20050	S,H,N,R	150	L	Wasser-und Schiffahrtsverwaltung	Früh.Pr.Wbv.Weserstrombauverwaltg. Hannover	Weserstrombauverwaltung Hannover	1
Hollenstein	1926	Schwarzer Regen	Viechtach	B	PG	18,0	74	25	2300	H,R	500	V	Kraftwerk am Hollenstein AG Straubing	AG für Energiewirtschaft Bamberg	Wayss & Freytag KG München	2
Schwarzenbach	1926	Schwarzenbach	Karlsruhe	BW	PG	65,50	380	290	14300	H	80	V	Stadt Karlsruhe	Direktion Karlsruhe	Siemens-Bauunion	3
Agger	1929	Agger	Gummersbach	NRW	PG	45,40	225	100	19300	H,C,S	51	L	Aggerverband Niederseßmar	Aggertalsperrengenossenschaft	Aggertalsperrengenossenschaft	4
Finsing	1929	Isarkanal	München	B	ER	13,0	15000	2000	34700	H	1300	V	Bayernwerk AG München	Mittlere Isar GmbH München	Stöhr & Bauwens, München Philipp Holzmann, München	5
Schwarza	1931	Schwarza	St. Blasien	BW	PG	43,0	158	44	1300	H	235	L	Schluchseewerk AG	Schluchseewerk AG	plusieurs entrepreneurs	6
Söse	1931	Söse	Osterode	NS	TE	56,0	485	1975	25450	C,S	90	L	Harzwasserwerke des Landes Niedersachsen	Harzwasserwerke des Landes Niedersachsen	plusieurs entrepreneurs	7
Schluchsee	1932	Schluchsee	St. Blasien	BW	PG	63,50	250	124	108000	H	190	L	Schluchseewerk AG	Schluchseewerk AG	plusieurs entrepreneurs	8
Oder	1934	Oder	Bad Lauterberg	NS	TE	62,0	310	1470	30610	C,H	93	L	Harzwasserwerke des Landes Niedersachsen	Harzwasserwerke des Landes Niedersachsen	plusieurs entrepreneurs	9
Driedorf	1935	Rehbach	Herborn	H	TE	19,0	460	125	1100	H,C	21	L	Elektrizitätswerke AG Mitteldeutschland, Kassel	Siemens-Schuckertwerke AG Erlangen und Berlin	plusieurs entrepreneurs	10
Heimbach	1935	Rur	Schleiden	NRW	PG	14,0	100	3,4	1500	S	450	V	Talsperrenverband Eifel-Rur (TVER)	Talsperrenverband Eifel-Rur (TVER)	Hochtief AG Essen	11
Kall	1935	Kall	Monschau	NRW	TE	41,0	180	244	2090	S	51,5	L	Wasserwerk des Landkreises Aachen	Wasserwerk des Landkreises Aachen	Grünzig-Bauwens Beton-u.Monierbau	12
Sorpe	1935	Sorpe	Neheim-Hüsten	NRW	TE	69,0	700	3380	70000	S	81,3	L	Ruhrtalsperrenverein	Ruhrtalsperrenverein	plusieurs entrepreneurs	13
Steinbach	1936	Steinbach	Euskirchen	NRW	TE	18,00	240	100	1200	I,S	15,4	L	Zweckverband Steinbachtalsperre	Prof.Dr.-Ing. Franzius Hannover	Fa. Kallenbach u.a.	14
Bever	1939	Beverbach	Wuppertal	NRW	TE	49,0	520	985	23700	C,S,R	97	V	Wupperverband	Wupperverband	Lenz Bau AG Dortmund	15
Alb	1941	Alb	St. Blasien	BW	PG	28,0	152	25	2200	H	248	V	Schluchseewerk AG	Schluchseewerk AG	Lahmeyer & Co. Frankfurt Brenzinger & Co. Freiburg	16
Schevelinger	1941	Schevelinger	Wuppertal	NRW	TE	22,0	150	52	300	C,S	24	L	Wupperverband	Wupperverband	Deutsche Tiefbau AG Essen	17
Ecker	1942	Ecker	Bad Harzburg	NS	PG	65,0	235	168	12640	C,S,H	31	L	Harzwasserwerke des Landes Niedersachsen	Harzwasserwerke des Landes Niedersachsen	Dyckerhoff & Widmann KG	18
Mettma	1943	Mettma	Waldshut	BW	PG	45,0	132	38	1700	H	80	V	Schluchseewerk AG	Schluchseewerk AG	plusieurs entrepreneurs	19
Witznau	1943	Schwarza	Waldshut	BW	PG	49,0	116	63	1350	H	260	V	Schluchseewerk AG	Schluchseewerk AG	plusieurs entrepreneurs	20
Krombach	1949	Rehbach	Herborn	H	TE	15,0	550	125,55	4200	H,C	27,6	L	Elektrizitäts-AG. Mitteldeutschland Kassel	Siemens-Schuckertwerke AG Erlangen und Berlin	Philipp Holzmann AG	21
Trausnitz	1952	Pfreimd	Nabburg	B	PG	20	150	20	2500	H,R	400	V	Energieversorgung Ostbayern AG., Regensburg	Energieversorgung Ostbayern AG., Regensburg	Kunz & Co., München Riepl, Regensburg	22
Verse	1952	Verse	Lüdenscheid	NRW	TE	62,0	320	1362	32800	S	39	L	Ruhrtalsperrenverein	Ruhrtalsperrenverein	plusieurs entrepreneurs	23
Genkel	1953	Genkel	Gummersbach	NRW	TE	43,65	200	380	8200	C,S	17,4	L	Aggerverband	Aggerverband	Aggerverband	24
Roßhaupten (Lechstaustufe 1)	1953	Lech-Forggensee	Füssen	B	TE	41,0	320	698	165000	H,C,R	750	V	Bayer. Wasserkraftwerke AG München	Bayer. Wasserkraftwerke AG München	Hochtief AG., Kunz & Co., Grün & Billinger, Wayss & Freytag KG	25

NOTES
FOOTNOTES

Folio No2

PAYS *COUNTRY* **ALLEMAGNE (Rép. Féd.) GERMANY (Fed. Rep.)**

FOLIO No.2

LIGNE / LINE No	NOM DU BARRAGE / NAME OF DAM	ANNÉE D'ACHÈVEMENT / YEAR OF COMPLETION	SITUATION / LOCATION: COURS D'EAU / RIVER	VILLE LA PLUS PROCHE / NEAREST CITY	ETAT PROVINCE OU DEPARTEMENT / STATE PROVINCE OR COUNTY	TYPE	HAUTEUR AU DESSUS DE LA PLUS BASSE FONDATION / HEIGHT ABOVE LOWEST FOUNDATION (m)	LONGUEUR DE CRÊTE / LENGTH OF CREST (m)	VOLUME DU BARRAGE / VOLUME CONTENT OF DAM (10³ m³)	CAPACITE TOTALE DU RESERVOIR / GROSS CAPACITY OF RESERVOIR (10⁶ m³)	DESTINATION	PURPOSE	CAPACITE MAXIMALE DES EVACUATEURS / MAXIMUM DISCHARGE CAPACITY OF SPILLWAYS (m³/s)	TYPE DES EVACUATEURS / TYPE OF SPILLWAYS	PROPRIETAIRE / OWNER	BUREAU D'ETUDES / ENGINEERING BY	CONSTRUCTEUR / CONSTRUCTION BY	LIGNE / LINE No
1	YAN YEAN	1857	OFF-RIVER STORAGE	MELBOURNE	VICTORIA	TE	12	986	206	32 710	S		10	L	MELBOURNE & METROPOLITAN BOARD OF WORKS	WATER SUPPLY DEPARTMENT	MARTIN DALE & STEELE	1
2	LOWER RESERVOIR	1861 (2)	SANDY BAY RIVULET	HOBART	TASMANIA	TE	18	104		210	S				HOBART CITY COUNCIL			2
3	ENOGGERA	1866	ENOGGERA	BRISBANE	QUEENSLAND	TE	24	342	95	4 500	S		450	L	BRISBANE CITY COUNCIL	JOSEPH BRADY AND BRISBANE BOARD OF WATERWORKS	DONOVAN & HULSE	3
4	UPPER STONY CREEK NO. 1	1868	STONY CREEK	GEELONG	VICTORIA	TE	29	404		3 420	S		40	L	GEELONG WATERWORKS & SEWERAGE TRUST	VICTORIAN WATER SUPPLY	JOHOTHAN CHAPPELL	4
5	SPRING GULLY	1868 (2)	SPRING CREEK	BENDIGO	VICTORIA	TE	24	512		2 467	S		4	L	STATE RIVERS & WATER SUPPLY COMMISSION, VICTORIA			5
6	BARKER'S CREEK	1869	BARKER'S CREEK	CASTLEMAINE	VICTORIA	TE	13	684		2 677	S		4	L	STATE RIVERS & WATER SUPPLY COMMISSION, VICTORIA			6
7	MALMSBURY	1870 (2)	COLIBAN	KYNETON	VICTORIA	TE	24	639		17 762	S		736	V	STATE RIVERS & WATER SUPPLY COMMISSION, VICTORIA	S.R.& W.S.COMMISSION, VICTORIA (FOR ENLARGEMENT)	S.R.& W.S.COMMISSION, VICTORIA (FOR ENLARGEMENT)	7
8	NEWLYN	1871 (2)	BULLAROOK CREEK	DAYLESFORD	VICTORIA	TE	12	683		3 330	S		255	L	STATE RIVERS & WATER SUPPLY COMMISSION, VICTORIA	STATE RIVERS & WATER SUPPLY COMMISSION, VICTORIA	STATE RIVERS & WATER SUPPLY COMMISSION, VICTORIA	8
9	HOPE VALLEY	1872	TORRENS	ADELAIDE	STH.AUST.	TE	22	765	236	3 440	S		12	L	STH.AUST.GOVERNMENT ENG. & WATER SUPPLY DEPARTMENT	STH.AUST.GOVERNMENT ENG. & WATER SUPPLY DEPARTMENT	G.& R.E.FRY AND STH.AUST.GOVT. ENG. & WATER SUPPLY DEPARTMENT	9
10	CRUSOE	1873	-	BENDIGO	VICTORIA	TE	12	624		1 480	S		4	L	STATE RIVERS & WATER SUPPLY COMMISSION, VICTORIA			10
11	LOWER STONY CREEK	1875	STONY CREEK	GEELONG	VICTORIA	PG	21	69	4	640	S		45	L	GEELONG WATERWORKS & SEWERAGE TRUST	VICTORIAN WATER SUPPLY		11
12	GONG GONG	1877	FELLMONGERS CREEK	BALLARAT	VICTORIA	TE	30	278		1 830	S		8	L	BALLARAT WATER COMMISSION			12
13	GOLD CREEK	1885	GOLD	BRISBANE	QUEENSLAND	TE	26	191	106	990	S		-	L	BRISBANE CITY COUNCIL	J.B.HENDERSON AND BRISBANE BOARD OF WATERWORKS	ROSS & DUNBAR	13
14	EVANSFORD	1887 (2)	MCCALLUMS CREEK	MARYBOROUGH	VICTORIA	PG	17	76		1 620	S		227	L	MARYBOROUGH WATER WORKS TRUST			14
15	WARTOOK	1887	MCKENZIE	STAWELL	VICTORIA	TE	11	1 416		29 357	S		566	L	STATE RIVERS & WATER SUPPLY COMMISSION, VICTORIA			15
16	UPPER RESERVOIR	1888 (2)	SANDY BAY RIVULET	HOBART	TASMANIA	TE	18	204		290	S				HOBART CITY COUNCIL			16
17	PROSPECT	1888 (2)	PROSPECT CREEK	SYDNEY	N.S.W.	TE	26 (2)	2 225	1 913	50 200	S		14 +	L	METROPOLITAN WATER SEWERAGE & DRAINAGE BOARD, SYDNEY	DEPARTMENT OF PUBLIC WORKS, N.S.W.	DEPARTMENT OF PUBLIC WORKS, N.S.W.	17
18	MT. COLE	1889 (2)	MT. COLE	ARARAT	VICTORIA	VA	24	112		400	S		-	L	ARARAT CITY WATER SUPPLY COMMISSION	B.A. & D.B. SMITH		18
19	GOULBURN WEIR (NAGAMBIE RES.)	1890	GOULBURN	NAGAMBIE	VICTORIA	PG	15	212	14	35 401	I		1 897	V	STATE RIVERS & WATER SUPPLY COMMISSION, VICTORIA			19
20	BEETALOO	1890	CRYSTAL BROOK CREEK	PT. PIRIE	STH.AUST.	PG	37	179	44	3 680	S		80	L	STH.AUST. GOVERNMENT ENG. & WATER SUPPLY DEPARTMENT	STH.AUST.GOVERNMENT ENG. & WATER SUPPLY DEPARTMENT		20
21	LAANECOORIE	1891	LODDON	MARYBOROUGH	VICTORIA	TE	22	399		7 771	I		71	V	STATE RIVERS & WATER SUPPLY COMMISSION, VICTORIA			21
22	VICTORIA RESERVOIR	1891	MUNDAY'S BROOK	PERTH	WEST AUST.	PG	31	229		900	S		150	L	M.W.S.S. & D.D., PERTH			22
23	MANLY	1892 (2)	CURL CURL CREEK	SYDNEY	N.S.W.	PG	20 (2)	256	8	2 000	C		178	L	METROPOLITAN WATER SEWERAGE & DRAINAGE BOARD, SYDNEY	DEPARTMENT OF PUBLIC WORKS, N.S.W.	DEPARTMENT OF PUBLIC WORKS, N.S.W.	23
24	STEPHENS CREEK	1892 (2)	STEPHENS CREEK	BROKEN HILL	N.S.W.	TE	18 (17)	256	72	24 325 + (17 885)	S		91	L	BROKEN HILL WATER BOARD	BROKEN HILL WATER SUPPLY CO.	BROKEN HILL WATER SUPPLY CO.	24
25	BETHUNGRA	1895	WANDALY-BENGLE CREEK	BETHUNGRA	N.S.W.	PG		161		580	S		120	L	NORTHERN RIVERINA COUNTY COUNCIL	DEPARTMENT OF PUBLIC WORKS, N.S.W.		25

NOTES / FOOTNOTES

(2) AS REQUIRED FOR WATER SUPPLY.
(5) RAISED 1929.
(7) RAISED 1940.
(8) RAISED 1961.
(14) RAISED 1940.
(16) AS REQUIRED FOR WATER SUPPLY.
(17) RAISED 0.5M IN 1898. + DISCHARGE CAPACITY AT 0.3M HEAD.
(18) RAISED 1926.
(23) RAISED 0.5M IN 1909, 0.5M IN 1914 AND 6M IN 1922.
(24) RAISED 1909 - BRACKETED FIGURES REFER TO ORIGINAL STRUCTURE.
+ DUE TO SILTATION, 20 554 IN 1969.

Folio No 1

PAYS / COUNTRY: AUSTRALIE / AUSTRALIA

FOLIO No.1

REGISTRE DES BARRAGES EN AUSTRALIE
REGISTER OF DAMS IN AUSTRALIA

FOLIO No. 2

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
LIGNE *LINE* No	NOM DU BARRAGE *NAME OF DAM*	ANNEE D'ACHEVEMENT *YEAR OF COMPLETION*	SITUATION *LOCATION* COURS D'EAU *RIVER*	VILLE LA PLUS PROCHE *NEAREST CITY*	ETAT PROVINCE OU DEPARTEMENT *STATE PROVINCE OR COUNTY*	TYPE	HAUTEUR AU DESSUS DE LA PLUS BASSE FONDATION *HEIGHT ABOVE LOWEST FOUNDATION* (m)	LONGUEUR DE CRETE *LENGTH OF CREST* (m)	VOLUME DU BARRAGE *VOLUME CONTENT OF DAM* (10^3 m)	CAPACITE TOTALE DU RESERVOIR *GROSS CAPACITY OF RESERVOIR* (10^3 m)	DESTINATION *PURPOSE*	CAPACITE MAXIMALE DES EVACUATEURS *MAXIMUM DISCHARGE CAPACITY OF SPILLWAYS* (m^3/s)	TYPE DES EVACUATEURS *TYPE OF SPILLWAYS*	PROPRIETAIRE *OWNER*	BUREAU D'ETUDES *ENGINEERING BY*	CONSTRUCTEUR *CONSTRUCTION BY*
1	KORUMBURRA	1895 ::	COALITION CREEK	KORUMBURRA	VICTORIA	TE	15	208		130	S		L	KORUMBURRA WATER WORKS TRUST		
2	HAPPY VALLEY	1896	ONKAPARINGA	ADELAIDE	STH.AUST.	TE	34	806	536	14 350	S	91	V	STH.AUST.GOVERNMENT ENG. & WATER SUPPLY DEPARTMENT	STH.AUST.GOVERNMENT ENG. & WATER SUPPLY DEPARTMENT	STH.AUST.GOVERNMENT ENG. & WATER SUPPLY DEPARTMENT
3	CLARENDON WEIR	1896	ONKAPARINGA	ADELAIDE	STH.AUST.	PG	19	81	47	330	S	1 031	L	STH.AUST.GOVERNMENT ENG. & WATER SUPPLY DEPARTMENT	STH.AUST.GOVERNMENT ENG. & WATER SUPPLY DEPARTMENT	J.WISHART & SON AND STH.AUST. GOVT.ENG. & WATER SUPPLY DEPT.
4	JUNCTION REEFS	1897 ::	BELUBULA	MANDURAMA	N.S.W.	MV	19	100	15	7 300	H			LYNDHURST GOLDFIELDS COY. LTD.	LYNDHURST GOLDFIELDS COY. LTD.	LYNDHURST GOLDFIELDS COY. LTD.
5	MOORES CREEK	1898	MOORES CREEK	TAMWORTH	N.S.W.	VA	19	155		220	S	250	L	TAMWORTH CITY COUNCIL	DEPARTMENT OF PUBLIC WORKS, N.S.W.	
6	NECTAR BROOK	1899	NECTAR BROOK	PT.AUGUSTA	STH.AUST.	TE	24	464	158	700	S	96	L	STH.AUST.GOVERNMENT ENG. & WATER SUPPLY DEPARTMENT	STH.AUST.GOVERNMENT ENG. & WATER SUPPLY DEPARTMENT	STH.AUST.GOVERNMENT ENG. & WATER SUPPLY DEPARTMENT
7	REDBANK CREEK	1899	REDBANK CREEK	MUDGEE	N.S.W.	VA	16	152	5	180	S	35	L	MUDGEE COUNCIL		
8	FROME	1900 ::	FROME	WELDBOROUGH	TASMANIA	ER	18	202		2	H	80	L	B.M.I. MINING PTY. LTD.		C. G. RYAN
9	RETURN CREEK	1900 ::	RETURN CREEK	CAIRNS	QUEENSLAND	ER	19	189		6 790	I,S			TABLELAND TIN DREDGING	HORNIBROOK, QUEENSLAND	HORNIBROOK, QUEENSLAND
10	BUNDALEER	1902	BROUGHTON	PT.PIRIE	STH.AUST.	TE	38	334	292	6 300	S	99	L	STH.AUST.GOVERNMENT ENG. & WATER SUPPLY DEPARTMENT	STH.AUST.GOVERNMENT ENG. & WATER SUPPLY DEPARTMENT	STH.AUST.GOVERNMENT ENG. & WATER SUPPLY DEPARTMENT
11	BAROSSA	1902	SOUTH PARA	ADELAIDE	STH.AUST.	VA	36	144	14	4 470	S	16	L	STH.AUST.GOVERNMENT ENG. & WATER SUPPLY DEPARTMENT	STH.AUST.GOVERNMENT ENG. & WATER SUPPLY DEPARTMENT	STH.AUST.GOVERNMENT ENG. & WATER SUPPLY DEPARTMENT
12	MUNDARING	1902 ::	HELENA	PERTH	WEST AUST.	PG	71	308	124	76 390	S	1 019	V	PUBLIC WORKS DEPARTMENT, WEST AUST.	PUBLIC WORKS DEPARTMENT, WEST AUST.	PUBLIC WORKS DEPARTMENT, WEST AUST.
13	UPPER COLIBAN	1903 ::	COLIBAN	KYNETON	VICTORIA	TE	28	406	182	31 500	I,S	284	L +	STATE RIVERS & WATER SUPPLY COMMISSION, VICTORIA		
14	PEKINA	1905	PEKINA CREEK	PT.PIRIE	STH.AUST.	TE	24	146	72	1 080	I	354	L	STH.AUST.GOVERNMENT DEPARTMENT OF LANDS	STH.AUST.GOVERNMENT ENG. & WATER SUPPLY DEPARTMENT	STH.AUST.GOVERNMENT ENG. & WATER SUPPLY DEPARTMENT
15	CATARACT	1907 ::	CATARACT	WOLLONGONG	N.S.W.	PG	59	247	112	94 300	S	634 ::	L	METROPOLITAN WATER SEWERAGE & DRAINAGE BOARD, SYDNEY	DEPARTMENT OF PUBLIC WORKS, N.S.W.	DEPARTMENT OF PUBLIC WORKS, N.S.W.
16	LITHGOW NO. 2	1907 ::	FARMER'S CREEK	LITHGOW	N.S.W.	VA	27 (26)	70 (70)	5	440	S	30	L	LITHGOW CITY COUNCIL	DEPARTMENT OF PUBLIC WORKS, N.S.W.	F. J. CARSON
17	LAKE MEDLOW	1907 ::	WALL'S CREEK	MEDLOW BATH	N.S.W.	VA	20	53	1	290	S	::	::	BLUE MOUNTAINS CITY COUNCIL	DEPARTMENT OF PUBLIC WORKS, N.S.W.	DEPARTMENT OF PUBLIC WORKS, N.S.W.
18	CASCADE NO. 1	1908 ::	CASCADE CREEK	KATOOMBA	N.S.W.	VA	17	112	4	150	S	4	L	BLUE MOUNTAINS CITY COUNCIL	DEPARTMENT OF PUBLIC WORKS, N.S.W.	GILMORE & CONNELL
19	WARANGA	1910	(SWAMP)	RUSHWORTH	VICTORIA	TE	12	7 001		411 242	I			STATE RIVERS & WATER SUPPLY COMMISSION, VICTORIA		
20	KORWEINGUBOORA	1910	E.MOORABOOL	BALLARAT	VICTORIA	TE	12	623		2 091	S	190	L	GEELONG WATERWORKS & SEWERAGE TRUST	VICTORIAN WATER SUPPLY	ALEXANDER LYNCH
21	PYKES CREEK	1911	PYKES AND MYERS CKS.	BALLAN	VICTORIA	TE	39	443		23 930	I,S	292	L	STATE RIVERS & WATER SUPPLY COMMISSION, VICTORIA	STATE RIVERS & WATER SUPPLY COMMISSION, VICTORIA	STATE RIVERS & WATER SUPPLY COMMISSION, VICTORIA
22	LANCE CREEK	1911	LANCE CREEK	WONTHAGGI	VICTORIA	TE	17	192		1 918	S	108	L	STATE RIVERS & WATER SUPPLY COMMISSION, VICTORIA	J. & H. COANE	J. & H. COANE
23	BEARGAMIL	1912	BEARGAMIL CREEK	PARKES	N.S.W.	TE	17	309	34	740	S	180	L	PARKES MUNICIPAL COUNCIL	DEPARTMENT OF PUBLIC WORKS, N.S.W.	DEPARTMENT OF PUBLIC WORKS, N.S.W.
24	YELDULKNIE	1912	YELDULKNIE CREEK	WHYALLA	STH.AUST.	PG	20	108	5	730	S	85	L	STH.AUST.GOVERNMENT ENG. & WATER SUPPLY DEPARTMENT	STH.AUST.GOVERNMENT ENG. & WATER SUPPLY DEPARTMENT	LEWIS & REID
25	ULLABIDINIE	1914	ULLABIDINIE CREEK	WHYALLA	STH.AUST.	PG	27	109	8	510	S	71	L	STH.AUST.GOVERNMENT ENG. & WATER SUPPLY DEPARTMENT	STH.AUST.GOVERNMENT ENG. & WATER SUPPLY DEPARTMENT	ATKINS & FINLAYSON

NOTES *FOOTNOTES*
(1) RAISED 1924.
(4) DATE APPROXIMATE.
(13) RAISED 1925. + PARTLY SIPHONIC, PARTLY DROP-BAR CONTROL.
(15) SUBJECT TO REVIEW.

Australia Folio No2

REGISTRE DES BARRAGES EN AUSTRALIE
REGISTER OF DAMS IN AUSTRALIA

FOLIO No. 3

2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
NOM DU BARRAGE *NAME OF DAM*	ANNEE D'ACHEVEMENT *YEAR OF COMPLETION*	SITUATION *LOCATION* COURS D'EAU *RIVER*	VILLE LA PLUS PROCHE *NEAREST CITY*	ETAT PROVINCE OU DEPARTEMENT *STATE PROVINCE OR COUNTY*	TYPE	HAUTEUR AU DESSUS DE LA PLUS BASSE FONDATION *HEIGHT ABOVE LOWEST FOUNDATION* (m)	LONGUEUR DE CRETE *LENGTH OF CREST* (m)	VOLUME DU BARRAGE *VOLUME CONTENT OF DAM* (10^3 m³)	CAPACITE TOTALE DU RESERVOIR *GROSS CAPACITY OF RESERVOIR* (10^3 m³)	DESTINATION	PURPOSE	CAPACITE MAXIMALE DES EVACUATEURS *MAXIMUM DISCHARGE CAPACITY OF SPILLWAYS* (m³/s)	TYPE DES EVACUATEURS *TYPE OF SPILLWAYS*	PROPRIETAIRE *OWNER*	BUREAU D'ETUDES *ENGINEERING BY*	CONSTRUCTEUR *CONSTRUCTION BY*	LIGNE *LINE* No
MOORABOOL	1915	WEST MOORABOOL	BALLARAT	VICTORIA	TE	18	744		6 640	S		L	BALLARAT WATER COMMISSION			1
UMBERUMBERKA	1915 ::	UMBERUMBERKA CREEK	BROKEN HILL	N.S.W.	PG/VA	41	212	41	13 175	S	300	L	BROKEN HILL WATER BOARD	DEPARTMENT OF PUBLIC WORKS, N.S.W.	DEPARTMENT OF PUBLIC WORKS, N.S.W.	2
UPPER CORDEAUX NO. 2	1915	CORDEAUX	WOLLONGONG	N.S.W.	PG	22	277	12	1 200	S	226	L	METROPOLITAN WATER SEWERAGE & DRAINAGE BOARD, SYDNEY	DEPARTMENT OF PUBLIC WORKS, N.S.W.	DEPARTMENT OF PUBLIC WORKS, N.S.W.	3
COTTER	1915 ::	COTTER	CANBERRA	A.C.T.	PG	31	118	26	4 650	S	850	L	COMMONWEALTH OF AUSTRALIA	COMMONWEALTH DEPARTMENT OF WORKS	COMMONWEALTH DEPARTMENT OF WORKS	4
LAKE MANCHESTER	1916	CABBAGE TREE	BRISBANE	QUEENSLAND	PG	38	227	45	25 690	S	380	L	BRISBANE CITY COUNCIL	METROPOLITAN WATER SUPPLY & SEWERAGE BOARD	ARTHUR MIDSON	5
HARVEY	1916 ::	HARVEY	HARVEY	WEST AUST.	PG	24	334	95	10 320	1,S	57	V +	PUBLIC WORKS DEPARTMENT, WEST AUST.	PUBLIC WORKS DEPARTMENT, WEST AUST.	PUBLIC WORKS DEPARTMENT, WEST AUST.	6
MELTON	1916 ::	WERRIBEE	BACCHUS MARSH	VICTORIA	ER	35	334		17 145	I	2 209	V,L	STATE RIVERS & WATER SUPPLY COMMISSION, VICTORIA	STATE RIVERS & WATER SUPPLY COMMISSION, VICTORIA	STATE RIVERS & WATER SUPPLY COMMISSION, VICTORIA	7
WARREN	1916	SOUTH PARA	ADELAIDE	STH.AUST.	PG	26	116	10	6 300	S	85	L	STH.AUST.GOVERNMENT ENG. & WATER SUPPLY DEPARTMENT	STH.AUST.GOVERNMENT ENG. & WATER SUPPLY DEPARTMENT	ATKINS & FINLAYSON	8
HINDMARSH VALLEY	1917	HINDMARSH	ADELAIDE	STH.AUST.	TE	21	216	64	460	S	10	L	STH.AUST.GOVERNMENT ENG. & WATER SUPPLY DEPARTMENT	STH.AUST.GOVERNMENT ENG. & WATER SUPPLY DEPARTMENT		9
MILLBROOK	1918	TORRENS	ADELAIDE	STH.AUST.	TE	36	291	282	16 390	S	170	L	STH.AUST.GOVERNMENT ENG. & WATER SUPPLY DEPARTMENT	STH.AUST.GOVERNMENT ENG. & WATER SUPPLY DEPARTMENT	STH.AUST.GOVERNMENT ENG. & WATER SUPPLY DEPARTMENT	10
BEACONSFIELD	1918	HAUNTED GULLY	MELBOURNE	VICTORIA	TE	24	171		936	S	21	L	STATE RIVERS & WATER SUPPLY COMMISSION, VICTORIA			11
RIDGEWAY	1919	VINCENT'S CREEK	HOBART	TASMANIA	VA	59	220	28	930	P	NIL	–	HOBART CITY COUNCIL	HOBART CITY COUNCIL	CORNWELL & CO. AND HOBART CITY COUNCIL	12
FRANKSTON	1920	SWEETWATER CREEK	MELBOURNE	VICTORIA	TE	19	256		691	S	21	L	STATE RIVERS & WATER SUPPLY COMMISSION, VICTORIA	STATE RIVERS & WATER SUPPLY COMMISSION, VICTORIA	STATE RIVERS & WATER SUPPLY COMMISSION, VICTORIA	13
BAROOTA	1921	BAROOTA CREEK	PT. PIRIE	STH.AUST.	TE	37	301	409	6 170	S	198	L	STH.AUST. GOVERNMENT ENG. & WATER SUPPLY DEPARTMENT	STH.AUST. GOVERNMENT ENG. & WATER SUPPLY DEPARTMENT	ATKINS & FINLAYSON	14
TOD RIVER	1922	TOD	PORT LINCOLN	STH.AUST.	TE	32	351	308	11 210	S	102	L	STH.AUST.GOVERNMENT ENG. & WATER SUPPLY DEPARTMENT	STH.AUST.GOVERNMENT ENG. & WATER SUPPLY DEPARTMENT	CONCRETE STEEL CONTRACTING AND MR. S. KIDMAN	15
MIENA (GREAT LAKE RES.)	1922 ::	SHANNON	HOBART	TASMANIA	MV	24	329		1 790 000	H	NIL	–	HYDRO-ELECTRIC COMMISSION, TASMANIA	HYDRO-ELECTRIC COMMISSION, TASMANIA	HYDRO-ELECTRIC COMMISSION, TASMANIA	16
CHICHESTER	1923 ::	CHICHESTER	MAITLAND	N.S.W.	PG	41	254	91	17 740	S	1 812	L	HUNTER DISTRICT WATER BOARD	DEPARTMENT OF PUBLIC WORKS, N.S.W.	DEPARTMENT OF PUBLIC WORKS, N.S.W.	17
TAYLOR'S LAKE	1923	NAT.DEPRESS	HORSHAM	VICTORIA	TE	12	2 354		37 004	I			STATE RIVERS & WATER SUPPLY COMMISSION, VICTORIA			18
MCKILN GULLY	1924	HUMPHREY'S RIVULET	GLENORCHY	TASMANIA	TE	26	165		460	S			GLENORCHY COUNCIL	H. HUTCHESSON	ARMSTRONG-WHITWORTH PTY. LTD.	1
YALLOURN WEIR	1924 ::	LATROBE	YALLOURN	VICTORIA	PG	12	59	2	490	S +	4 100	V	STATE ELECTRICITY COMMISSION, VICTORIA	STATE ELECTRICITY COMMISSION, VICTORIA	STATE ELECTRICITY COMMISSION, VICTORIA	20
CORDEAUX	1926 ::	CORDEAUX	WOLLONGONG	N.S.W.	VA/PG	58	404	167	93 600	S	566 ::	L	METROPOLITAN WATER SEWERAGE & DRAINAGE BOARD, SYDNEY	DEPARTMENT OF PUBLIC WORKS, N.S.W.	DEPARTMENT OF PUBLIC WORKS, N.S.W.	21
CASCADE NO. 2	1926	CASCADE CREEK	KATOOMBA	N.S.W.	TE	26	128	82	340	S	132	L	BLUE MOUNTAINS CITY COUNCIL	DEPARTMENT OF PUBLIC WORKS, N.S.W.	DEPARTMENT OF PUBLIC WORKS, N.S.W.	22
BURRINJUCK	1927 ::															23
EILDON	1927 ::	GOULBURN	ALEXANDRA	VICTORIA	TE/ER	79	1 043	10 410	3 392 070	I,H	2 548	V	STATE RIVERS & WATER SUPPLY COMMISSION, VICTORIA	S.R.& W.S.COMMISSION, VICTORIA AND UTAH (AUST.) LTD.	S.R.& W.S.COMMISSION, VICTORIA AND UTAH (AUST.) LTD.	24
GLENMAGGIE	1927 ::	MACALISTER	SALE	VICTORIA	VA/PG	37	295	77	189 956		2 775	V	STATE RIVERS & WATER SUPPLY COMMISSION, VICTORIA	STATE RIVERS & WATER SUPPLY COMMISSION, VICTORIA	STATE RIVERS & WATER SUPPLY COMMISSION, VICTORIA	25

NOTES *REMARKS*

(2) DUE TO SILTATION, 8 162 IN 1969.
(4) RAISED 1951.
(6) RAISED 1931. + STOPBOARD CONTROL.
(7) RAISED 1937, 1967 – FIGURES RELATE TO 1967 RAISING.
(16) SUPERSEDED BY NEW DAM – SEE PAGE 10 LINE [illegible]
(20) DESTROYED BY FLOOD DECEMBER 1934 – REBUILT 1935 – SEE PAGE 4 LINE 22. + COOLING WATER FOR THERMAL POWER STATION.
(21) SUBJECT TO REVIEW.
(23) ORIGINAL DAM 1927, RAISED 1956 – SEE PAGE 6 LINE 16.

Australia Folio No 3

AUSTR. COUN

AUSTR PAY

FOLIO

REGISTER OF DAMS IN UNITED-STATES

FOLIO No. 1

1 LIGNE LINE No	2 NOM DU BARRAGE NAME OF DAM	3 ANNEE D'ACHEVEMENT YEAR OF COMPLETION	4 SITUATION LOCATION COURS D'EAU RIVER	5 VILLE LA PLUS PROCHE NEAREST CITY	6 ETAT PROVINCE OU DEPARTEMENT STATE PROVINCE OR COUNTY	7 TYPE	8 HAUTEUR AU DESSUS DE LA PLUS BASSE FONDATION HEIGHT ABOVE LOWEST FOUNDATION (m)	9 LONGUEUR DE CRÊTE LENGTH OF CREST (m)	10 VOLUME DU BARRAGE VOLUME CONTENT OF DAM (10^3 m^3)	11 CAPACITE TOTALE DU RESERVOIR GROSS CAPACITY OF RESERVOIR (10^3 m^3)	12 DESTINATION PURPOSE	13 CAPACITE MAXIMALE DES EVACUATEURS MAXIMUM DISCHARGE CAPACITY OF SPILLWAYS (m^3/s)	14 TYPE DES EVACUATEURS TYPE OF SPILLWAYS	15 PROPRIÉTAIRE OWNER	16 BUREAU D'ETUDES ENGINEERING BY	17 CONSTRUCTEUR CONSTRUCTION BY	18 LIGNE LINE No
1	Lake Drummond	1825	Lake Drummond	Suffolk	Virginia	TE				27,137	NS		V	Corps of Engineers			1
2	Buckeye Lake	1831	S. F. Licking		Ohio					34 000	NR			State of Ohio			2
3	Upper Tumbling Run	1836	Tumbling Run	N. Manheim	Pa.	TE	18	174		900	S			Silver Creek Water Co.			3
4	Beaverdam Lake	1840	Beaverdam Creek		Wis.					600	S			City of Beaver Dam			4
5	Lake St. Marys	1841	Beaver & Jenkins Cr.		Ohio					113,400				State of Ohio			5
6	Upper Peak Lake	1850	Trib S. Fork Yuba River	Auburn	Calif.	TEER	11	88	5	1,982	H	7.?	L	Pacific Gas and Electric Co.		South Yuba Water Co.	6
7	Upper Cascade Lake Reussen's	1850	James	Lynchburg	Va.	PG	16	229		3,300	H			American Electric Power			7
8	Silver Creek	1850	Silver Cr.	Pottsville	Pa.	TE	274			800	S			Blythe Township Municipal Auth.	Elwood Morris	Charles Barber	8
9	Indian Lake	1851	Miami		Ohio					57,000	S			State of Ohio			9
10	Rabbit Run	1852	Rabbit Run	Tamaqua	Pa.	TE	17	198		800	S			Borough of Tamaqua			10
11	Kidd Lake	1855	S. F. Yuba		Calif.	TE	12	131	8	1,840	H	5.7	L	Pacific Gas and Electric Co.		South Yuba Water Co.	11
12	French Lake	1859	Canyon Cr.	Nevada	Calif.	ER	30	61		17,100	IHS			Nevada Irrigation District			12
13	Lake Cochituate	1863	Sudbury		Mass.					8,000				Metropolitan District Commission			13
14	Meadow Lake	1864	Trib Fordyce Cr.	Sacramento	Calif.	TEER	11	311	30.3	>,920	H	16	L	Pacific Gas & Electric		South Yuba Water Co.	14
15	Baskahegan Lake	1865	Baskahegan Stream		Maine					69,100				Baskahegan Dam Co.			15
16	Bidwell Lake	1865	N. Canyon Cr.		Calif.	TEER	11	85	31	6,000	IS			Clara Bidwell Estate			16
17	Cranberry Lake	1867	E. Branch Oswegatchi		N. Y.					72,000				Commission for improvement of Oswegatchi River			17
18	Lake Temescal	1869	Temescal Cr.		Calif.	TE	34	198	262.3	600	S			East Bay Reg. Park District			18
19	Derby	1870	Housatonic	Shelton	Conn.	PG	13	206		6,000	INS			Shelton Canal Co.	H. T. Potter		19
20	Fuller Lake	1870	Jordan Cr.	Sacramento	Calif.	TE	11	111	5.?	1,307	H	10	L	Pacific Gas and Electric Co.		Meager Mining Co.	20
21	Green Lake	1870	Puchyan		Wis.	TE				6,200	S			Town of Green Lake			21
22	Lac Vieux Desert	1870	Wisconsin		Wis.					17,000	HC			Wisconsin Valley Improvement Co.			22
23	Druids Lake	1871		Baltimore	Md.	TE	36			2,000							23
24	Shenipsit Lake	1871	Hockanum		Conn.					18,000	HS			Rockville Water And Aquaduct Co.			24
25	Lagunitas	1872	Lagunitas Cr.	San Raphael	Calif.	TE	15	132	65	400	S			Marin Municipal Water District			25

NOTES
FOOTNOTES

United States
Folio No. 1

UNITED STATES — ETATS-UNIS
COUNTRY — PAYS
FOLIO No.

LIGNE / LINE No	NOM DU BARRAGE / NAME OF DAM	ANNÉE D'ACHÈVEMENT / YEAR OF COMPLETION	SITUATION / LOCATION: COURS D'EAU / RIVER	SITUATION: VILLE LA PLUS PROCHE / NEAREST CITY	SITUATION: ETAT PROVINCE OU DÉPARTEMENT / STATE PROVINCE OR COUNTY	TYPE	HAUTEUR AU DESSUS DE LA PLUS BASSE FONDATION / HEIGHT ABOVE LOWEST FOUNDATION (m)	LONGUEUR DE CRÊTE / LENGTH OF CREST (m)	VOLUME DU BARRAGE / VOLUME CONTENT OF DAM (10^3 m^3)	CAPACITÉ TOTALE DU RÉSERVOIR / GROSS CAPACITY OF RESERVOIR (10^3 m^3)	DESTINATION / PURPOSE	CAPACITÉ MAXIMALE DES ÉVACUATEURS / MAXIMUM DISCHARGE CAPACITY OF SPILLWAYS (m^3/s)	TYPE DES ÉVACUATEURS / TYPE OF SPILLWAYS	PROPRIÉTAIRE / OWNER	BUREAU D'ÉTUDES / ENGINEERING BY	CONSTRUCTEUR / CONSTRUCTION BY
1	Boyd Corners	1873	W. Br. of Croton	Kent Cliffs	N. Y.	PG	24	204	191.1	10,300	S			City of New York	Dept. of Public Works of N. Y.	Roach and Jenkins
2	Eisenhuth	1874	Eisenhuth	Shenandoah	Pa.	TE		411		1,100	S			Pottsville Water Co.		
3	Pilarcitos	1874 (a)	Pilarcitos Creek	Millbrae	Calif.	TE	29	158	284	4,000	S			City of San Francisco	Spring Valley Water Co.; Calvin	Brown and Hernan Schussler
4	Flat River	1875	S. Br. Pawtuxet		R. I.					7,100	H			Fruit of Loom Co.		
5	Burlingame	1876	Trib San Francisco Bay		Calif.	TE	26	123	36	100	I			Dr. and Mrs. Frank D. Lorenz		
6	Carmel Middle Branch	1878	W. Br. Croton	Brewster	N. Y.	PG	27	157	301.2	16,000	S			City of New York	Dept. of Public Works of New York	M. S. Coleman and Belden and Denison
7	Eagle and Phoenis Mills	1878	Chattahoochee	Columbus	Ga.	TE	11				H					
8	Echo Lake	1876	Truckee	Sacramento	Calif.	TE	3.7	98	2.7	2344	H	31	L	Pacific Gas and Electric Co.	El Dorado Power Co.; H.M. Byllesby Co.	
9	Sebago Lake	1878	Presumpscot		Maine					275,100	HS			S. D. Warren Co.		
10	St. Helena, Lower	1878	Napa	St. Helena	Calif.	TE	15	261	23	300	S			City of St. Helena		
11	Mud Run	1879	Mud Run	Frackville	Pa.	TE		343		800	S			Mahoney Township Authority	George S. Clemens	
12	Antietam Creek Stony Creek	1880	Antietam Cr.	Reading	Pa.	TE	18	70	6	400	S			City of Reading	HPH Birkinbine	Christian Eben
13	Bear Lake	1880	Bear Creek		Wis.		11			13,400	H			Northern States Power Co.		
14	Griffin	1880	Griffin Cr.	Scranton	Pa.	TEPG		114		2,000				Pa. Gas and Water Co.		
15	Lake Yosemite	1880	San Joaquin	Merced	Calif.	TE	16	1,448	266.4	9,000	I			Merced Irrigation District	A. A. Blakesley	
16	Old Forge	1880 (b)	Middle Br. Moose		N. Y.		18			25,000	HCN			State of New York		
17	Phoenis	1880	Sullivan Cr.	Modesto	Calif.	TE	12	242	22	1,050	IHS	109	V	Pacific Gas and Electric Co.		Tuolumne County Water & Electric Power Co.
18	Rangeley Lake	1880	Rangeley Stream		Maine		16			70,000	H (c)			Union Water Power Co.		
19	Sixth Lake	1880	Moose		New York		14			8,200	CN			Black River Regulating District		
20	Stony Creek	1880	Stony Creek	Reading	Pa.	TEMV	18	70	6.2	400	S			City of Reading		
21	Birchwood	1882	Red Cedar		Wis.					17,100	H			Northern States Power Co.		
22	Cedar Falls	1882	Red Cedar	Menomonie	Wis.	CB	17	76		16,300	H			Northern States Power Co.		
23	Cedar Lake	1882	Red Cedar		Wis.					16,300	H			Northern States Power Co.		
24	Salt Springs Valley	1882	Rock Creek	Farmington	Calif.	TE	18	652	114	23,400	IS			Rock Creek Water District		
25	Indian Run	1884	Indian Run	Birdsboro	Pa.	TE	12	113		100	S			Birdsboro Water Co.		

NOTES / FOOTNOTES
a) Original Construction in 1866
b) Original Construction in 1800
c) Logging

Folio No 2

PAYS / COUNTRY: ETATS-UNIS / UNITED-STATES

LIGNE LINE No	NOM DU BARRAGE NAME OF DAM	ANNEE D'ACHEVEMENT YEAR OF COMPLETION	SITUATION LOCATION: COURS D'EAU RIVER	VILLE LA PLUS PROCHE NEAREST CITY	ETAT PROVINCE OU DEPARTEMENT STATE PROVINCE OR COUNTY	TYPE	HAUTEUR AU DESSUS DE LA PLUS BASSE FONDATION HEIGHT ABOVE LOWEST FOUNDATION (m)	LONGUEUR DE CRETE LENGTH OF CREST (m)	VOLUME DU BARRAGE VOLUME CONTENT OF DAM (10³ m³)	CAPACITE TOTALE DU RESERVOIR GROSS CAPACITY OF RESERVOIR (10⁶ m³)	DESTINATION (VOIR CODE)	CAPACITE MAXIMALE DES EVACUATEURS MAXIMUM DISCHARGE CAPACITY OF SPILLWAYS (m³/s)	TYPE DES EVACUATEURS TYPE OF SPILLWAYS	PROPRIETAIRE OWNER	BUREAU D'ETUDES ENGINEERING BY	CONSTRUCTEUR CONSTRUCTION BY
1	Leech Lake Federal Dam	1884	Leech Lake	Federal Dam	Minnesota	TE	4.6	1,100		916,860	CNR			Corps of Engineers		
2	Loon Lake	1884	Gerle Cr.		Calif.	PG	11	198	15.3	10,000	I			Georgetown Divide Public Utilities District		
3	Number 2	1884	W. Br. Hammer Cr.	Lebanon	Pa.	TE		213		200	S			City of Lebanon		
4	Pokegama	1884	Mississippi	Grand Rapids	Minn.	TE	4.6	117.3		149,000	CNR			Corps of Engineers		
5	Waste House Run #1	1884	Waste House Run	Shenandoah	Pa.	TE	122			200	S			Mahonoy Township Authority	George S. Clemens	
6	Winnibigoshish	1884	Mississippi	Deer River	Minn.	TE	8.8	304.8		1,193,900	CNR		V	Corps of Engineers		
7	Number 3	1885	Lost Creek	Shenandoah	Pa.	TE		320		300				Borough of Shenandoah	Heber S. Thompson	Tho. H. Rickert
8	Paddy	1885	Paddy Cr.		Calif.	TE	17	82	32.2	200	S			California Pacific Utility Co.		
9	Curlis	1886	Oak Run	Scranton	Pa.	TE		111		200				Pa. Gas and Water Co.	E. Sherman Gould	Burks Brothers
10	Pine River Cross Lake	1886	Pine River	Cross Lake	Minn.	TE	7.3	431.3		218,900	CNR		V	Corps of Engineers		
11	Temescal	1886 (a)	Temescal Cr.	Oakland	Calif.	TF	39	198	200.3	1,100	S			Oakland Water Supply District		
12	Cuyamaca	1887	Boulder Cr.	Julian	Calif	TE	12	203	24,850	14,501	S (b)		L	Helix Irrigation District		
13	Pole Run #4	1887	Pole Run	Mahonoy	Pa.	TE		213		100	S			Mahonoy Township Authority	Mark D. Bowman	Mahonoy City Water Co.
14	Pontook	1887	Androscoggin	Berlin	N. H.	ER (c)	84	4		1,500	H			Union Water Power Co.		
15	Big St. Germaine Lake	1888	St. Germaine Cr.		Wis.					7,000	HC			Wisconsin Valley Improvement Co.		
16	Brush Mountain	1888	Kettle Cr.	Altoona	Pa.	TE	16	262		700	S			Blair Gap Water Supply Co.		
17	Errol	1888	Androscoggin	Errol	N. H.	TE			(d)	87,200	H			Union Water Power Co.		
18	Home Supply Mariano or Bodecker	1888	Off Channel	Loveland	Colo.	TE		701		11,300	I			Home Supply Ditch Co.	W. W. Wheeler	
19	Little Quinnesee Falls	1888	Menomonee	Niagara	Wis.	PG	21	17			H			Kimberly-Clark Co.		
20	Oliphant #2	1888	Grassy Island Cr.	Oliphant	Pa.	TEPG	18	103		200	S			Pa. Gas and Water Co.	Frank Wolf	Burke Brothers
21	Otis	1888 (e)	W. Br. Farmington		Conn.					22,100	H			Farmington River Water Power Co.		
22	Sequoia Lake	1888	Mill Flat Cr.	Fresno	Calif.	TEER	16	69	9.2	4,000	R			YMCA Conference		
23	Sweetwater-Main	1888	Sweetwater	San Diego	Calif.	PG	39	213	411.1	34,100	IS			Sweetwater Water Corp.	J. D. Schuyler	
24	Elmhurst	1889	Roaring Brook	Elmhurst	Pa.	TEPG	21	117		5,000	S			Pa. Gas and Water Co.	E. Sherman Gould	Burke Brothers
25	Jeannette	1889	Br. Brush Cr.	Greensburg	Pa.	TE		165		300	R			Mrs. Helen Indyk		

NOTES
FOOTNOTES

a) Original construction 1868
b) Cuyamaca is also used for Recreation (Fishing, Duck hunting and Picnicing)
c) Double walled masonery earthfill embankment
d) Timber and concrete cribs
e) Original construction in 1865

Folio No 3

PAYS COUNTRY ETATS-UNIS UNITED STATES

REGISTER OF DAMS IN UNITED-STATES

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
LIGNE *LINE* No	NOM DU BARRAGE *NAME OF DAM*	ANNÉE D'ACHÈVEMENT *YEAR OF COMPLETION*	SITUATION *LOCATION* COURS D'EAU *RIVER*	VILLE LA PLUS PROCHE *NEAREST CITY*	ETAT PROVINCE OU DÉPARTEMENT *STATE PROVINCE OR COUNTY*	TYPE	HAUTEUR AU DESSUS DE LA PLUS BASSE FONDATION *HEIGHT ABOVE LOWEST FOUNDATION* (m)	LONGUEUR DE CRÊTE *LENGTH OF CREST* (m)	VOLUME DU BARRAGE *VOLUME CONTENT OF DAM* (10^3 m^3)	CAPACITÉ TOTALE DU RÉSERVOIR *GROSS CAPACITY OF RESERVOIR* (10^3 m^3)	DESTINATION *PURPOSE*	CAPACITÉ MAXIMALE DES ÉVACUATEURS *MAXIMUM DISCHARGE CAPACITY OF SPILLWAYS* (m^3/s)	TYPE DES ÉVACUATEURS *TYPE OF SPILLWAYS*	PROPRIÉTAIRE *OWNER*	BUREAU D'ÉTUDES *ENGINEERING BY*	CONSTRUCTEUR *CONSTRUCTION BY*
1	Nevers	1889	St. Croix		Wis.	CB	14	823		14,200	H					
2	Pokegama	1889	Mississippi		Minn.	PG				149,000	CNR			Corps of Engineers		
3	Clinton	1890	Pequannock		N. J.	TE	12	488		13,300	S			City of Newark		
4	Corvell	1890		Santa Cruz	Calif.	TE	15	85	23	200	S			City of Santa Cruz		
5	Crocker	1890	S. Sanchez Creek	San Mateo	Calif.	TE	14	61	8.4		I			Provident Security Co.		
6	Marshall Lake	1890	Off Channel	Boulder	Colo.	TE	26	661		13,000	I			Farmers Reservoir & Irrigation Co.	J. E. Hays	
7	Port Costa	1890	Carquinez Strait		Calif.	TE	14	73	16.1	100	IS			Calif. Water Service Co.		
8	Searsville	1890	Corte Madera	Palo Alto	Calif.	TE	27	79	12.2	1,200	I			Stanford University	Herman Schussler	H. C. Vensano
9	Crystal Springs - Upper	1891	San Mateo Creek	San Mateo	Calif.	TE	28	158	169	16,000	S			City of San Francisco	Spring Valley Water Co; Herman Schussler	
10	Dunmore #1	1891	Little Roaring Brook	Scranton	Pa.	TE	11	142		400	S			Pa. Gas and Water Co.		
11	Julesburg (Jumbo)	1891	Off Channel	Sedwick	Colo.	TE		613		34,000	I			Julesburg Irrigation Co.		
12																
13																
14																
15																
16																
17																
18																
19																
20																
21																
22																
23																
24																
25																

NOTES
FOOTNOTES

Folio No 4

PAYS *COUNTRY* **ETATS-UNIS UNITED-STATES**

FOLIO No 4

REGISTRE DES BARRAGES AUX ETATS-UNIS
REGISTER OF DAMS IN UNITED-STATES

FOLIO No.

1 LIGNE *LINE* No	2 NOM DU BARRAGE *NAME OF DAM*	3 ANNEE D'ACHEVEMENT *YEAR OF COMPLETION*	4 SITUATION *LOCATION* COURS D'EAU *RIVER*	5 VILLE LA PLUS PROCHE *NEAREST CITY*	6 ETAT PROVINCE OU DEPARTEMENT *STATE PROVINCE OR COUNTY*	7 TYPE	8 HAUTEUR AU-DESSUS DE LA PLUS BASSE FONDATION *HEIGHT ABOVE LOWEST FOUNDATION* (m)	9 LONGUEUR DE CRÊTE *LENGTH OF CREST* (m)	10 VOLUME DU BARRAGE *VOLUME CONTENT OF DAM* (10^3 m^3)	11 CAPACITÉ TOTALE DU RÉSERVOIR *GROSS CAPACITY OF RESERVOIR* (10^3 m^3)	12 DESTINATION *PURPOSE*	13 CAPACITÉ MAXIMALE DES EVACUATEURS *MAXIMUM DISCHARGE CAPACITY OF SPILLWAYS* (m^3/s)	14 TYPE DES EVACUATEURS *TYPE OF SPILLWAYS*	15 PROPRIÉTAIRE *OWNER*	16 BUREAU D'ÉTUDES *ENGINEERING BY*	17 CONSTRUCTEUR *CONSTRUCTION B*
1	Ash Fork (Steel Dam #1)	1898	Johnsons Canyon	Ash Fork	Ariz.	TEPG	14	91	.001	100	S			Atchison, Topeka & Santa Fe Railway	F. H. Bainbridge & J. H. Jackson	
2	Bradford #3	1898	Marilla Cr.	Bradford	Pa.	TE	12	241		500	S			Bradford Municipal Water Works		
3	Crystal Reservoir	1898	W.Br. Schuylkill	Pottsville	Pa.	TE		137		200	S			Blythe Township Municipal Authority		
4	Drury #1	1898	Crow Cr.	Briggsdale	Colo.	TE				5,100	I			Drury Land & Irrigation Co.		P. Guinn
5	Indian Lake	1898	Indian		N. Y.	TEPG	14	96		141 000	HCNS			Indian River Co.		
6	Lake Scranton	1898	Stafford Meadow Brook	Scranton	Pa.	TEER	18	180		10,000	S			Pa. Gas & Water Co.	Alphonse F. Teley	Burke Brothers
7	Mill Creek Storage	1898	Mill Creek	Wilkesbarre	Pa.	TEPG		394		2,300	S			Pa. Gas & Water Co.		
8	Seligman	1898		Seligman	Ariz.	PG	21	196	36	900	S			Atchison, Topeka & Santa Fe Railway		
9	Steel Dam (Ash Fork 3-6)	1898	Johnson's Canyon	Ash Fork	Ariz.	MV (a)	14	241		490	S		L	Atchison, Topeka & Santa Fe Railway Co.		
10	Sudbury	1898	Sudbury	Southbor-ough	Mass.	TE	2>	591	267	27,500	S			Commonwealth of Mass.	Commonwealth of Mass.	Moulton & O'Mahoney
11	Suisun Municipal	1898	Suisun Cr.		Calif.	TE	18	137		200	H			Suisun City		
12																
13																
14																
15																
16																
17																
18																
19																
20																
21																
22																
23																
24																
25																

NOTES
FOOTNOTES a) Steel Arches - Concrete Abutement

Folio No 11

LIGNE / LINE No.	NOM DU BARRAGE / NAME OF DAM	ANNEE D'ACHEVEMENT / YEAR OF COMPLETION	SITUATION / LOCATION: COURS D'EAU / RIVER	VILLE LA PLUS PROCHE / NEAREST CITY	ETAT PROVINCE OU DEPARTEMENT / STATE PROVINCE OR COUNTY	TYPE	HAUTEUR AU DESSUS DE LA PLUS BASSE FONDATION / HEIGHT ABOVE LOWEST FOUNDATION (m)	LONGUEUR DE CRÊTE / LENGTH OF CREST (m)	VOLUME DU BARRAGE / VOLUME CONTENT OF DAM (10³ m³)	CAPACITE TOTALE DU RESERVOIR / GROSS CAPACITY OF RESERVOIR (10³ m³)	DESTINATION / PURPOSE	CAPACITE MAXIMALE DES EVACUATEURS / MAXIMUM DISCHARGE CAPACITY OF SPILLWAYS (m³/s)	TYPE DES EVACUATEURS / TYPE OF SPILL WAYS	PROPRIETAIRE / OWNER	BUREAU D'ETUDES / ENGINEERING BY	CONSTRUCTEUR / CONSTRUCTION BY
1	Bear Rock #2	1904	Bear Rock Run	Lilly	Pa.	TE	11	250		100	IS			Summit Water Supply Co.	Pa. Railroad Co.	Mr. O'Rourke
2	Cheeseman	1904	S. Platte	Jefferson	Colo.	VA	72	216	79	98,000	S			City of Denver		Denver Union Water Co.
3	Colgate Head	1904	N. Fork Yuba		Calif.	PG	14	53	4		H			Pacific Gas & Electric Co.		
4	Cornell	1904	Chippewa	Cornell	Wis.	TEPG	15	226			H			Walter Brothers		
5	Daltons Run	1904	Daltons Run	Johnstown	Pa.	TE	19	204		500	S			Johnstown Water Co.		
6	Deer Rips	1904	Androscoggin	Lewiston	Maine	PG	21	256			H			Central Maine Power Co.		
7	Glenwood (Glenwood Lake)	1904				TE	18.3	30.5			H	67.96	V	Niagara Mohawk Power Corporation	A. L. Swett Electric Light & Power Co.	
8	Panama Reservoir #1	1904	Boulder Cr.	Boulder	Colo.		14			5,000	I					
9	Peddlar River	1904	Peddlar	Lynchburg	Va.	PG	15.2	27.4	5	4,564	S		V	City of Lynchburg	James Fuertes; Wiley & Wilson	
10	Tomhannock	1904	Tomhannock	Tray	N. Y.					46,000	S			City of Tray		
11	Wachusett North Dike	1904	Nashua	Clinton	Mass.	TE	25	3,383	4,205.1	254,000	S			Commonwealth of Mass.	Commonwealth of Mass.	Nawn & Brook; Newell & Snowling &McArthur Bros.
12	Wachusett South Dike	1904	Nashua	Clinton	Mass.	TE	45	892	327	254,000	S			Commonwealth of Mass.	Commonwealth of Mass.	John. F. Magee & Co.
13	Waialua	1904			Hawaii	TEER	30	140		10,000						
14																
15																
16																
17																
18																
19																
20																
21																
22																
23																
24																
25																

NOTES :
FOOTNOTES

Folio No 17

PAYS / COUNTRY: ETATS-UNIS / UNITED STATES

FOLIO No. 17

1 LIGNE LINE No	2 NOM DU BARRAGE NAME OF DAM	3 ANNÉE D'ACHÈVEMENT YEAR OF COMPLETION	4 SITUATION LOCATION COURS D'EAU RIVER	5 VILLE LA PLUS PROCHE NEAREST CITY	6 ETAT PROVINCE OU DEPARTEMENT STATE PROVINCE OR COUNTY	7 TYPE	8 HAUTEUR AU DESSUS DE LA PLUS BASSE FONDATION HEIGHT ABOVE LOWEST FOUNDATION (m)	9 LONGUEUR DE CRÊTE LENGTH OF CREST (m)	10 VOLUME DU BARRAGE VOLUME CONTENT OF DAM (10^3 m)	11 CAPACITÉ TOTALE DU RESERVOIR GROSS CAPACITY OF RESERVOIR (10^3 m³)	12 DESTINATION PURPOSE	13 CAPACITÉ MAXIMALE DES ÉVACUATEURS MAXIMUM DISCHARGE CAPACITY OF SPILLWAYS (m^3/s)	14 TYPE DES ÉVACUATEURS TYPE OF SPILL WAYS	15 PROPRIÉTAIRE OWNER	16 BUREAU D'ETUDES ENGINEERING BY	17 CONSTRUCTEUR CONSTRUCTION BY
1	Belvedere	1905	Widow Reed Creek		Calif.	TEER (a)	15	91	19.1		S			Marin Municipal Water District		
2	Blackbrook	1905				PG	33	160								
3	Dead River Pond	1905	Dead		Maine					6,400	H			Kennebec W ter Power Co.		
4	De Weese	1905	Grope Cr.	Canyon City	Colo.	PG	15			3,400						
5	Dry Creek	1905	Snake		Idaho					15,000	I			Twin Falls Canal Co.		
6	Empire	1905	S. Platte	Weld	Colo.	TE	12			47,000	I			Bijou Irrigation Co.		
7	Falling Springs	1905	Falling Springs Cr.	Pittston	Pa.	TE	18	425		1,000	S			Pa. Gas & Water Co.		
8	Finnon	1905	Jay Bird Cr.	Placerville	Calif.	TE		293	80	500	R			State Dept. of Fish & Game	American River Electric Co.	
9	Georgetown Lake	1905	Flint Cr.		Montana					38,200	HS			Montana Power Co.		
10	Hinckston Run	1905	Hinckston Run	Conemaugh	Pa.	TE	26	267		4,300	IS			Manufacturers Water Co.		
11	Indian Creek	1905	Indian Cr.	Connellsville	Pa.	ER	12	157		900	S			Mountain Water Supply Co.	American Pipe Manufacturing Co.	American Pipe Manufacturing
12	Indian Ford	1905	Rock		Wis.					6,200	H			Wis. Power & Light Co.		
13	Johnson	1905	Fremont		Utah					7,000	I			Fremont Irrigation Co.		
14	Koloa Marsh	1905			Hawaii					9,500	I			Grove Farm Co., Ltd.		
15	Lake Hamilton	1905	Yellow Cr.	Youngstown	Ohio	TE	20.4			2,800	S			Ohio Water Service Co.		
16	Milner	1905	Snake River	Burley	Idaho	ER					I		V	Twin Falls Canal Co.		
17	Murtaugh Lake (b)	1905	Snake-Off-stream	Twin Falls	Idaho	TE					I		L	Twin Falls Canal Co.		
18	Muscoot	1905	Croton	N. Y.	N. Y.	PG	21	61	249	22,000	S			City of New York	Aquaduct Commission of N. Y.	Williams & Gerstle; M. J. Fegan; Caldwell Wilcox
X 19	New Croton (Quaker Bridge; Cornell)	1905	Croton	Ossining	N. Y.	PG	91	661	1,109	90,000	S			City of N. Y.	Aquaduct Commission of N. Y.	Jas. S. Coleman; Coleman, R. Brown; Breuch & Coleman
20	Piedmont #2	1905	Trib San Fran. Bay	Oakland	Calif.	TE	16	76	25	100	S			East Bay Municipal Utility Dist.		
21	Redstone No. 3	1905	Redstone Cr.	Uniontown	Pa.	TEER	16	152		300	S			Uniontown Water Co.		
22	Saluda (c)	1905	Saluda	Greenville	S. C.	PG	15	83		9,000	H			Duke Power Co.		
23	Sheldon Springs	1905	Missisquoi	Sheldon	Vt.	CB	12	91			H			Missisquoi Pulp Co.	Ambursen Engineering Co.	Ambursen Engineering Co.
X 24	Spier Falls	1905	Hudson	Glens Falls	N. Y.	PG	45.7	249.5	137.6		H	2,548.5	V	Niagara Mohawk Power Corp.	C. F. Parsons	
25	St. Croix Falls	1905	St. Croix	St. Croix Falls	Wis.	PG	17	207			H			Northern States Power Co.		

NOTES
FOOTNOTES a) Gunite Facing
b) Flow diverted from Snake at Milner Dam
c) Purchased by Duke Power Co. in 1910

x Visited by LAB Wade

ETATS-UNIS COUNTRY UNITED-STATES

Folio No 18

REGISTRE DES BARRAGES AUX ETATS-UNIS
REGISTER OF DAMS IN UNITED-STATES

FOLIO No. 19

1 LIGNE *LINE* No	2 NOM DU BARRAGE *NAME OF DAM*	3 ANNÉE D'ACHÈVEMENT *YEAR OF COMPLETION*	4 SITUATION · *LOCATION* COURS D'EAU *RIVER*	5 VILLE LA PLUS PROCHE *NEAREST CITY*	6 ETAT PROVINCE OU DÉPARTEMENT *STATE PROVINCE OR COUNTY*	7 TYPE	8 HAUTEUR AU-DESSUS DE LA PLUS BASSE FONDATION *HEIGHT ABOVE LOWEST FOUNDATION* (m)	9 LONGUEUR DE CRÊTE *LENGTH OF CREST* (m)	10 VOLUME DU BARRAGE *VOLUME CONTENT OF DAM* (10^3 m^3)	11 CAPACITÉ TOTALE DU RÉSERVOIR *GROSS CAPACITY OF RESERVOIR* (10^3 m^3)	12 DESTINATION *PURPOSE*	13 CAPACITÉ MAXIMALE DES ÉVACUATEURS *MAXIMUM DISCHARGE CAPACITY OF SPILLWAYS* (m^3/s)	14 TYPE DES ÉVACUATEURS *TYPE OF SPILLWAYS*	15 PROPRIÉTAIRE *OWNER*	16 BUREAU D'ETUDES *ENGINEERING BY*	17 CONSTRUCTEUR *CONSTRUCTION BY*
1	Stillwater #1	1905	Yampa	Yampa	Colo.	TE	82	416		7,000	I			Yampa Res. Public Irrigation District	Dewey A. Dutton	
2	Storage	1905	Mill Run	Altoona	Pa.	TE	10	244		200	S			City of Altoona	Knight & Hopkins	H. S. Kerbaugh
3	Taylor Pond	1905	Black Brook		N. Y.					14,200	HC			New York State Electric & Gas Corporation		
4	Trap Falls	1905	Housa Tonic	Bridgeport	Conn.	PG	15	274	8.4	9,000	S			Bridgeport Hydraulic Co.		
5	Wahiawa	1905	Kau Konahua		Hawaii					10,000	I			Waialua Agricultural Co., Ltd.		
6	Wolf Creek	1905	Wolf Creek	Pottsville	Pa.	TE	21 ?			2,000	S			Pottsville Water Co.		
7							JMB									
8							13/11/94									
9																
10																
11																
12																
13																
14																
15																
16																
17																
18																
19																
20																
21																
22																
23																
24																
25																

NOTES
FOOTNOTES

Folio No 19

FOLIO
ETATS-UNIS
UNIT

LIGNE / LINE No	NOM DU BARRAGE / NAME OF DAM	ANNEE D'ACHEVEMENT / YEAR OF COMPLETION	SITUATION / LOCATION: COURS D'EAU / RIVER	VILLE LA PLUS PROCHE / NEAREST CITY	ETAT PROVINCE OU DEPARTEMENT / STATE PROVINCE OR COUNTY	TYPE	HAUTEUR AU DESSUS DE LA PLUS BASSE FONDATION / HEIGHT ABOVE LOWEST FOUNDATION (m)	LONGUEUR DE CRÊTE / LENGTH OF CREST (m)	VOLUME DU BARRAGE / VOLUME CONTENT OF DAM (10^3 m^3)	CAPACITE TOTALE DU RESERVOIR / GROSS CAPACITY OF RESERVOIR (10^3 m^3)	DESTINATION / PURPOSE	CAPACITÉ MAXIMALE DES ÉVACUATEURS / MAXIMUM DISCHARGE CAPACITY OF SPILLWAYS (m^3/s)	TYPE DES ÉVACUATEURS / TYPE OF SPILLWAYS	PROPRIÉTAIRE / OWNER	BUREAU D'ETUDES / ENGINEERING BY	CONSTRUCTEUR / CONSTRUCTION BY
1	Alpine	1906	Trib N. F. Stanislaus	Sonora	Calif.	ER	14	106	4	5,670	IHS	56.6	L	Pacific Gas & Electric Co.		
2	Animas	1906	Animas	Durango	Colo.	ER	27	229								
3	Brownell	1906	Racket Brook	Carbondale	Pa.	PG	18	187		3,200	S			Pa. Gas and Water Co.	William M. Maple	Birike Brothers
4	Campbell's Ledge	1906	Campbell's Ledge Cr.	Scranton	Pa.	TE	11	175		300	S			Pa. Gas & Water Co.	J. H. Lance	Spring Brook Supply Co.
5	Coeur d'Alene Lake	1906	Spokane		Idaho					294,200	H			Washington Water Power Co.		
6	Dolby	1906	W. Br. Penobscot	E. Millinocket	Maine	PG	24	422		6,000	S			Great Northern Paper Co.		
7	Fountain Valley #2	1906	Trib Fountain	Colorado Springs	Colo.	TE	18	872		6,300				Fountain Mutual Irrigation Co.	W. C. Seeley	
8	Glen Park	1906	Monument Cr.	Palmer Lake	Colo.		18	42		200	S			Denver and Rio Grande Railroad		
9	Hollidays Bridge	1906	Saluda	Bleton	S. C.	TEPG	12	196		8,000	H			Duke Power Co. (a)	J. E. Sirrine Co.	Gallivan Building Co.
10	Lake Gogebic	1906	W. Br. Ontonagon		Mich.					62,000	H			Upper Peninsula Power Co.		
11	Long Tom	1906	Long Tom Cr.	Mountain Home	Idaho	TE					I		L	Mountain Home Irrigation District		
12	Minidoka (Lake Walcott)	1906	Snake	Minidoka	Idaho	TE	27	1,364	197	259,000	IHC	2,520	L	Bureau of Reclamation	Bureau of Reclamation	Bates and Rodgers Construct Co.
13	Mountain Home	1906	Rattlesnake Cr.	Mountain Home	Idaho	TE	14			7,000	IS		L	Mountain Home Irrigation District		
14	Niagara	1906	Roanoke	Roanoke	Va.	PG	15.2	183			H			American Electric Power		
15	Post Falls	1906	Spokane	Post Falls	Idaho	PG	23			781,000	H			The Washington Water Power Co.	The Washington Water Power Co.	The Washington Water Power
16	Ricketts	1906	Ganoga Lake	Wilkes - Barre	Pa.	CB	16	183			S			A. B. Ricketts	Ambursen Engineering Corp.	Ambursen Engineering Corp.
17	Tunnel	1906	Quine Baug	Norwich	Conn.	PG	11	146		600	H			Connecticut Light & Power Co.	Harry H. Hope Engineering Co.	
18	Wachusett	1906	Nashua	Clinton	Mass.	PG	63	434	214.1	254,000	S			Commonwealth of Massachusetts	Commonwealth of Massachusetts	McArthur Brothers Co.
19																
20																
21																
22																
23																
24																
25																

NOTES
FOOTNOTES a) Purchased by Duke Power Co. in 1963

x Visited by LAB Wade.

Folio No 20

ETATS-UNIS / UNITED-STATES *COUNTRY*

REGISTER OF DAMS IN PERU

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
LIGNE *LINE* No	NOM DU BARRAGE *NAME OF DAM*	ANNÉE D'ACHÈVEMENT *YEAR OF COMPLETION*	SITUATION *LOCATION*			TYPE	HAUTEUR AU-DESSUS DE LA PLUS BASSE FONDATION *HEIGHT ABOVE LOWEST FOUNDATION* (m)	LONGUEUR DE CRÊTE *LENGTH OF CREST* (m)	VOLUME DU BARRAGE *VOLUME CONTENT OF DAM* (10^3 m^3)	CAPACITÉ TOTALE DU RÉSERVOIR *GROSS CAPACITY OF RESERVOIR* (10^3 m^3)	DESTINATION *PURPOSE*	CAPACITÉ MAXIMALE DES ÉVACUATEURS *MAXIMUM DISCHARGE CAPACITY OF SPILLWAYS* (m^3/s)	TYPE DES ÉVACUATEURS *TYPE OF SPILLWAYS*	PROPRIÉTAIRE *OWNER*	BUREAU D'ÉTUDES *ENGINEERING BY*	CONSTRUCTEUR *CONSTRUCTION BY*
			COURS D'EAU *RIVER*	VILLE LA PLUS PROCHE *NEAREST CITY*	ETAT PROVINCE OU DÉPARTEMENT *STATE PROVINCE OR COUNTY*											
1	Ahuashuman				Lima	PG	15.0			4,050	I		L	Ministerio de Agricultura		
2	Azulccocha		Chillón		Lima	PG				6,300	I		L	"		
3	Ancaccocha		Yauca		Arequipa	PG	13.0	37		13,750	I		L	"		
4	Carambita		Virú		La Libertad	PG	21.0	103		1,100	I		L	"		
5	Collique		Chancay	Chiclayo	Lambayeque	TE	11.0	1400		9,000	I		L	"		
6	Chancan		Chancay		Lima	PG	10.0	30		1,000	I		L	"		
7	Chumpicocha		Mala		Lima	PG				3,000	I		L	"		
8	Chuncho		San Juan	Huancayo	Ica	TE				26,000	I		L	"	Dirección de Aguas é Irrigación	Dirección de Aguas é Irrigació
9	Chungar		Chancay		Lima	PG	15.0	113		14,250	I		L	"		
10	Chu-chun		Chillón	Canta	Lima	PG				5,100	I		L	"		
11	Huarmiccocha		San Juan	Huancayo	Lima	TE				37,000	I		L	"	Dirección de Aguas é Irrigación	Dirección de Aguas é Irrigació
12	Pacococha		Sinto	Castrovi-rreyna	Huancaveli-ca	TE	11.0			12,000	I		L	"	"	"
13	Quisha		Chancay		Lima	PG	17.0	60		13,690	I		L	"		
14	Rahuite		Chancay		Lima	PG	12.0	65		3,100	I		L	"		
15	Uchumachay				Lima	PG	10.0			3,250	I		L			
16	Upamayo		Lago Junín	Cerro de Pasco	Junín	PG	10.0	83		300,000	I		L			
17	Yanacocha		Chillón		Lima	PE				7,300						
18	Yunoán				Lima	PG	12.0			5,600	I		L			
19	Carpa	1875	Huasca	Huanza	Lima	VA	20.0	50		17,800	IH		L	L'État		
20	Huasca	1875 1926	Huanza	Huanza	Lima	PG	12.0	63		6,200	IH		L	"		
21	Manca	1875 1940	Huachua	Huanza	Lima	PG	16.0	70	1.2	5,000	H		L	Empresas Eléctricas Asociadas	P. Bonner	Empresas Eléctricas Asociadas
22	Pucro	1875	Canchis	Huanza	Lima	PG	13.0	22		2,000	IH		L	L'Etat		
23	Sacsa	1875 1945	Sacsa	Acobamba	Lima	PG	16.0	140	4.0	14,900	IH		L	L'Etat		
24	Quisha	1875	Huasca	Huanza	Lima	VA	20.0	51		6,700	IH			L'Etat		
25	Pirhua	1876 1940	Yana	Huanza	Lima	PG	11.0	70		1,600	IH		L	L'Etat		

NOTES *FOOTNOTES*
Les doubles dates veulent dire que le barrage a été elevé a la seconde date
The double date means that the dam was heightened at the second date

Peru
Folio No 1

PAYS *COUNTRY* **PÉROU** **PERU**

REGISTRE DES BARRAGES EN AFRIQUE DU SUD
REGISTER OF DAMS IN THE REPUBLIC OF SOUTH AFRICA

FOLIO No. 1

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
LIGNE / LINE No.	NOM DU BARRAGE / NAME OF DAM	ANNÉE D'ACHÈVEMENT / YEAR OF COMPLETION	SITUATION - LOCATION: COURS D'EAU / RIVER	VILLE LA PLUS PROCHE / NEAREST CITY	ÉTAT PROVINCE OU DÉPARTEMENT / STATE PROVINCE OR COUNTRY	TYPE	SITUATION ET TYPE D'ÉTANCHÉITÉ / POSITION AND NATURE OF SEALING ELEMENT	FONDATION / FOUNDATION	HAUTEUR AU DESSUS DE LA PLUS BASSE FONDATION / HEIGHT ABOVE LOWEST FOUNDATION (m)	LONGUEUR DE CRÊTE / LENGTH OF CREST (m)	VOLUME DU BARRAGE / VOLUME CONTENT OF DAM (10^3 m^3)	CAPACITÉ TOTALE DU RÉSERVOIR / SURFACE DU RÉSERVOIR — GROSS CAPACITY OF RESERVOIR / RESERVOIR AREA (10^3 m^3) / (10^3 m^2)	DESTINATION	CAPACITÉ MAXIMALE DES ÉVACUATEURS / MAXIMUM DISCHARGE CAPACITY OF SPILLWAYS (m^3/s)	TYPE DES ÉVACUATEURS / TYPE OF SPILLWAYS	PROPRIÉTAIRE / OWNER	BUREAU D'ÉTUDES / ENGINEERING BY	CONSTRUCTEUR / CONSTRUCTION BY
1	VANWYKSVLEI	1884	Carnarvon	Vanwyksvlei	Cape Province	TE	ie	S	15	311	93	157 000 / 50 000	I	-	L	Vanwyksvlei IB	Garoubd Algina	Garoubd Algina
2	OUDTSHOORN	1885	-	Cape Town	Cape Province	TE	-	-	15*	460	-	188 / 30	S	-	L	Cape Town Municipality	J. Jennaud	-
3	VICTORIA	1897	Berg	Paarl	Cape Province	TE	-	-	15*	102	-	680 / 140	S	-	L	Paarl Municipality	-	-
4	WOODHEAD	1897	Tr Disa	Cape Town	Cape Province	PG	-	-	50	277	19	955 / 132	S	28	L	Cape Town Municipality	Thos Stewart	J. Delbridge & Municip.
5	MUSHROOM VALLEY	1902	Sand	Winburg	Orange Free State	TE	-	-	13*	1 000	-	3 000 / 2 000	I	-	L	W.H. Breslaar	-	-
6	KELLY HUTCHINSON	1904	Disa	Cape Town	Cape Province	PG	-	-	16	322	8	914 / 158	S	34	L	Cape Town Municipality	Thos Stewart	J. Delbridge
7	SAND RIVER PALMIET*	1905	Sand	Uitenhage	Cape Province	PG	-	-	26	160	26	2 670 / 320	S	165	L	Port Elizabeth Municip.	L. Ingham	Port Elizabeth Municip.
8	JAMESON	1906	-	Grahams-town	Cape Province	TE	-	-	15*	102	-	646 / 110	S	-	L	Grahamstown	-	-
9	BULK RIVER	1907	Bulk	Uitenhage	Cape Province	VA	-	-	26	203	26	821 / 126	S	128	L	Port Elizabeth Municip.	L. Ingham	Port Elizabeth Municip.
10	BONGOLO*	1908	Komani	Queenstown	Cape Province	PG/VA	-	-	24	118	14	6 943	S	227	L	Queenstown Municipality	Gellatly & Stewart	Roberts Construction
11	HELLGATE	1910	Klip	Uitenhage	Cape Province	VA	-	-	26	4	1	120	-	116	L	C.V. Naude	L. Ingham	RH Pough
12	BETHEL	1912	Berg	Paarl	Cape Province	TE	-	-	15*	204	-	543 / 130	S	-	L	Paarl Municipality	-	-
13	SMARTT SYNDICATE*	1912	Ongers & Brak	Britstown	Cape Province	TE	ie	R/S	28	1 082	307	38 000 / 31 170	I	1 420	I	Smartt IB	State (DWA)	State (DWA)
14	LUXTON	1913	Soutpoort	Luxton	Cape Province	TE	-	-	17	199	12	1 170 / -	I/S	218	L	Luxton Municipality	State (DWA)	State (DWA)
15	DE VILLIERS	1916	Disa	Cape Town	Cape Province	PG	-	-	30	126	6	243 / 39	S	6	L	Cape Town Municipality	Thos Stewart	J. Delbridge
16	SCHUILHOEK	1916	Tr Sand	Volksrust	Orange Free State	TE	-	-	19*	96	-	363 / 60	S	-	L	Volksrust Municipality	-	-
17	CALITZDORP	1917	Nels	Calitzdorp	Cape Province	PG/TE	-	-	34	207	46	4 989 / 502	I/S	340	L	Calitzdorp IB	State (DWA)	Calitzdorp IB
18	PRINS RIVER*	1917	Prins	Ladysmith	Cape Province	ER	fc	R/S	37	197	86	2 700 / 560	I	3 100	L	Prins River IB	State (DWA)	Prins River IB
19	BAKER	1918	Laughing Water	Willow-more	Cape Province	VA	-	-	17	168	6	406 / 120	S	120	L	SA Transport Services	-	-
20	BELLAIR	1920	Brak	Barrydale	Cape Province	TE	ie	R/S	20	198	151	11 000 / 1 979	I	110	L	Bellair IB	State (DWA)	Bellair IB
21	BETHULIE	1921	Bethulie	Bethulie	Orange Free State	VA	-	-	23	134	11	4 600 / 1 576	S	370	L	Bethulie Municipality	-	-
22	STEENBRAS*	1921	Steenbras	Somerset West	Cape Province	PG	-	-	36	412	51	33 500 / 3 651	S	481	L	Cape Town Municipality	FL Kanthack	Cementation Co Ltd
23	STOLTZ RIVER	1921	Stoltz	Beaufort West	Cape Province	TE	-	-	16	274	97	1 500	I	220	L	Private	State (DWA)	State (DWA)
24	VICTORIA WEST	1921	Tr Kruis	Victoria West	Cape Province	VA	-	-	25	133	-	3 660 / 2 081	S	103	L	Victoria West Municip.	Gellatly	Gellatly
25	LAKE MENTZ*	1922	Sundays	Kirkwood	Cape Province	PG	-	-	48	418	209	169 000 / 35 930	I	632	V	Sundays River IB	State (DWA)	State (DWA)

NOTES / FOOTNOTES

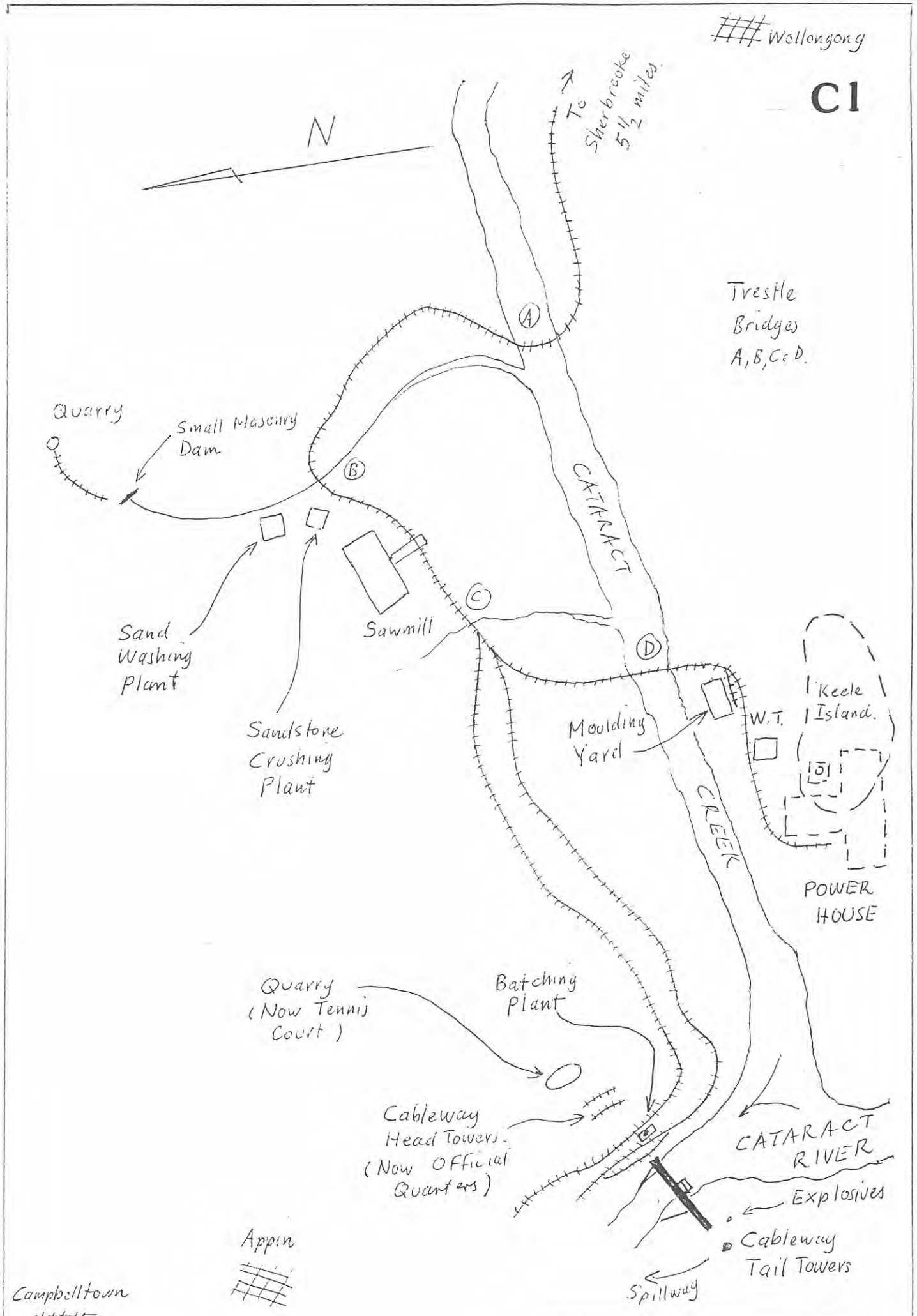
Heights indicated thus (*) are the height above downstream toe
(7) Raised 7.6m in 1929 (10) Raised 1.2m in 1934 (13) Raised 9m in 1950; 3m in 1954
(18) Raised 2.8m in 1962; 1.8m in 1986 (22) Raised 6m in 1924; 11.4m in 1927; 1.35m in 1954; 0.6m in 1957
(25) Raised 1.5m in 1935; 5.8m in 1951

South Africa
Folio No 1

B3

APPENDIX C

Drawings/Records	Reference
Layout Sketch	1
General Plan - (Figure 1) from 1984 Surveillance Report	2
Typical Cross Section (Figure 2) from 1984 Surveillance Report	3
Arrangement of Outlet Work (Figure 4) from 1984 Surveillance Report	4
General Arrangement of Dam Wall (Figure 2), from 1989 Surveillance Report	5
Lower Valve House (Figure 12) from 1989 Surveillance Report.	6


Wollongong
C1
N
To Sherbrooke 5½ miles
Trestle Bridges A, B, C & D.
A
B
C
D
Quarry
Small Masonry Dam
CATARACT
Sand Washing Plant
Sandstone Crushing Plant
Sawmill
Moulding Yard
W.T.
Keele Island.
51
CREEK
POWER HOUSE
Quarry (Now Tennis Court)
Batching Plant
Cableway Head Towers (Now Official Quarters)
CATARACT RIVER
Explosives
Cableway Tail Towers
Spillway
Appin
Campbelltown
JMB 15/11/94
N.T.S.
LAYOUT SKETCH

DEPARTMENT OF PUBLIC WORKS
RIVERS, WATER SUPPLY AND DRAINAGE BRANCH

CATARACT DAM

GENERAL PLAN

SCALE 50 FT = 1 INCH

T.W.L. 950

CONTRACT No. 563

DRAWING No. 1.

L A B Wade

Copy

E M de Burgh

H H Dare

DEPARTMENT OF PUBLIC WORKS
RIVERS, WATER SUPPLY AND DRAINAGE BRANCH.

CATARACT DAM

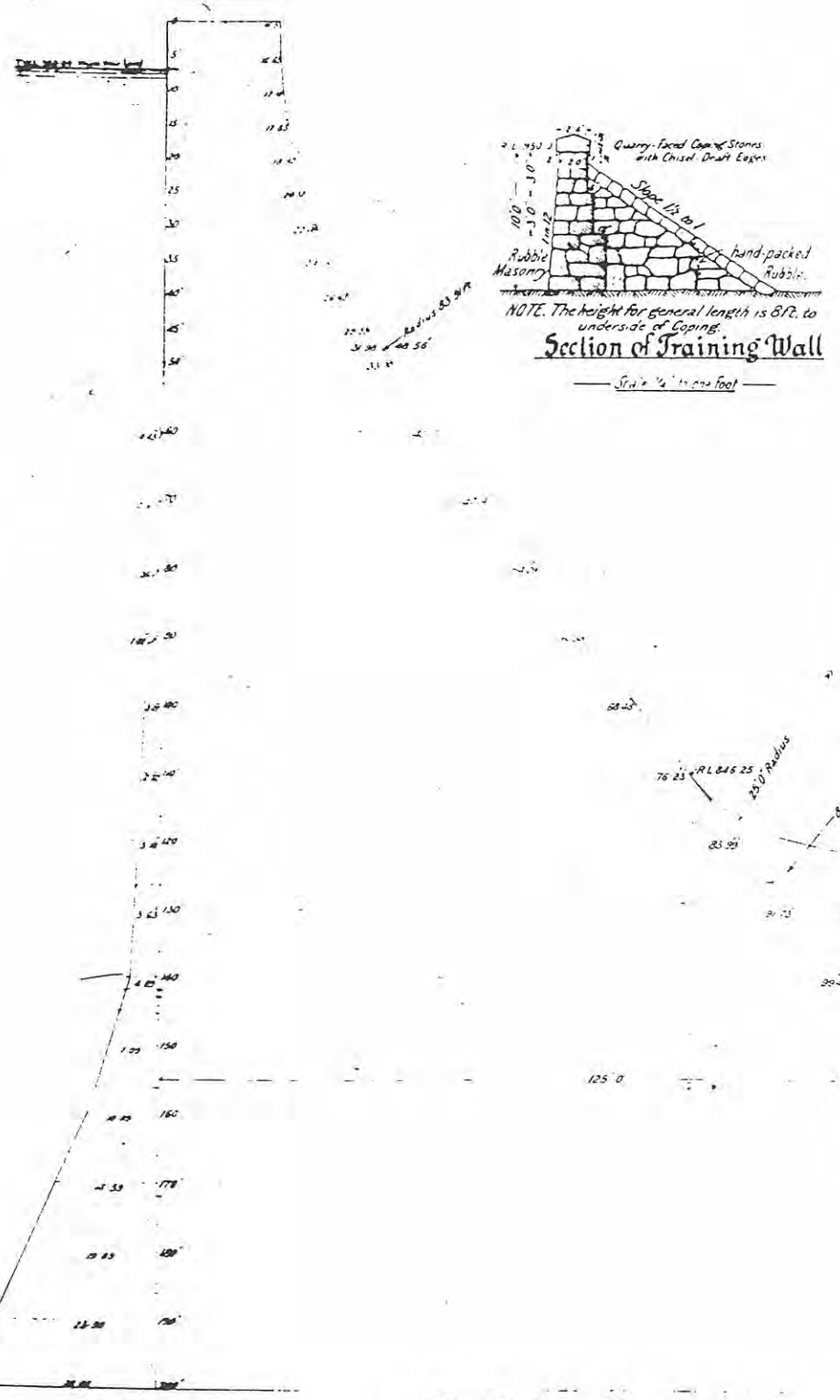
TYPICAL CROSS SECTION OF DAM & BYEWASHWALL

CONTRACT No. [illegible]
DRAWING No. 2

Copy

E

F.W.S. 252 LAB Wade



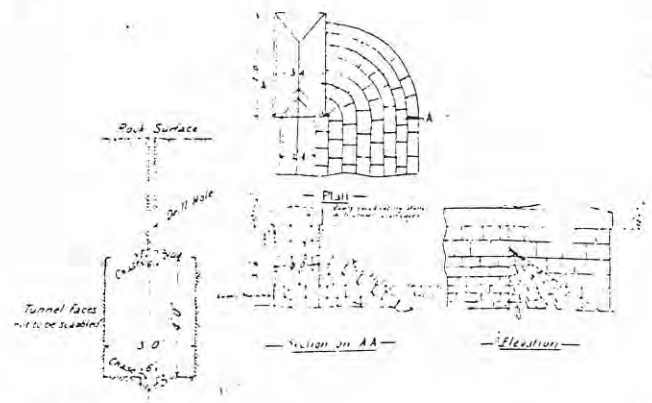
Type Section of Dam
Scale 1" to one foot

THEORETICAL PROFILE for approximate foundations see Cross Sections of Dam

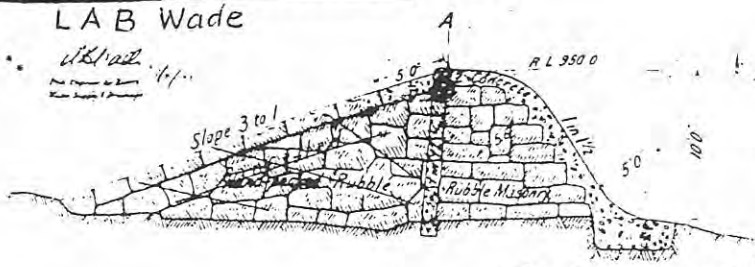
E M de Burgh

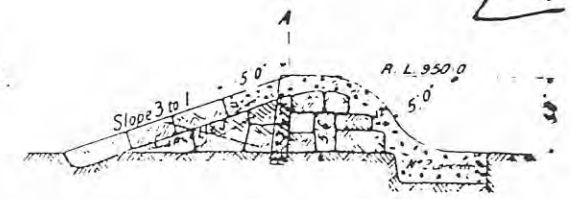
NOTE. The height for general length is 6ft. to underside of Coping.

Section of Training Wall
Scale 1/2" to one foot

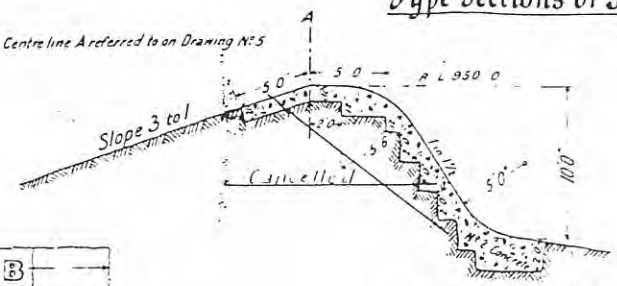


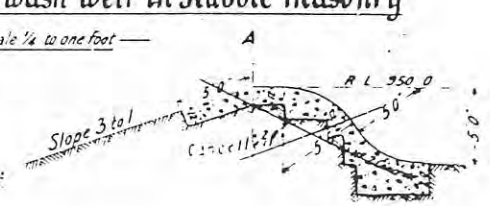
Section of Tunnel
(minimum size)
Scale 1/2" to one foot



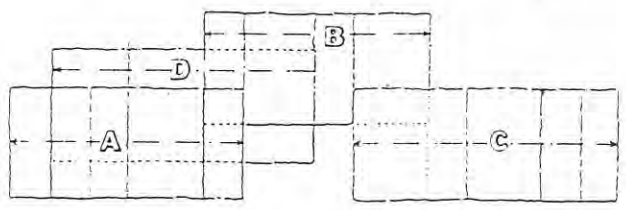


Type Sections of Bye-wash Weir in Rubble Masonry
Scale 1/4 to one foot

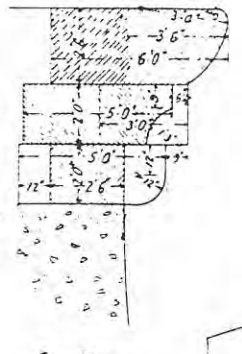




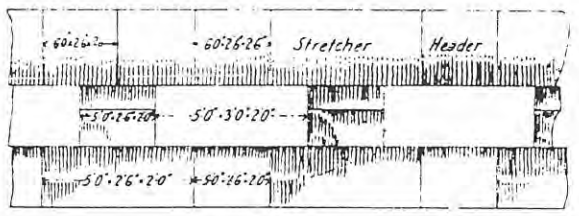
Type Sections of Bye-wash Weir in Rock



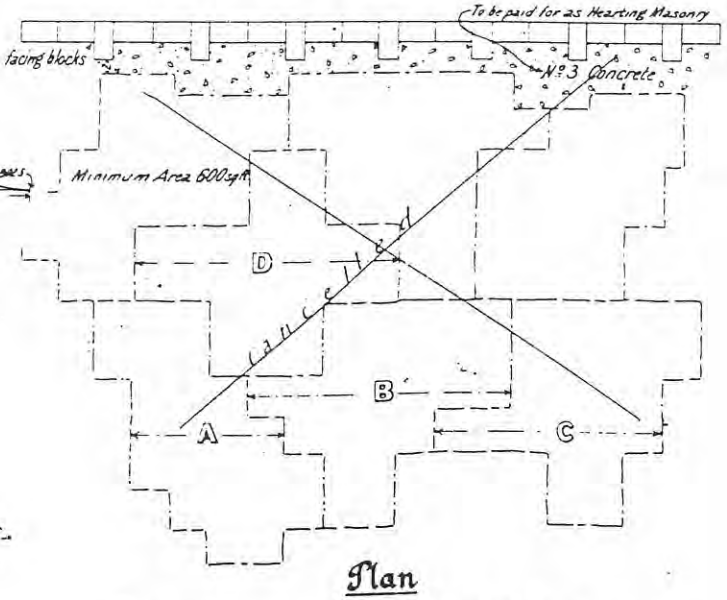
Elevation
Scale 1/8" to one foot



Section

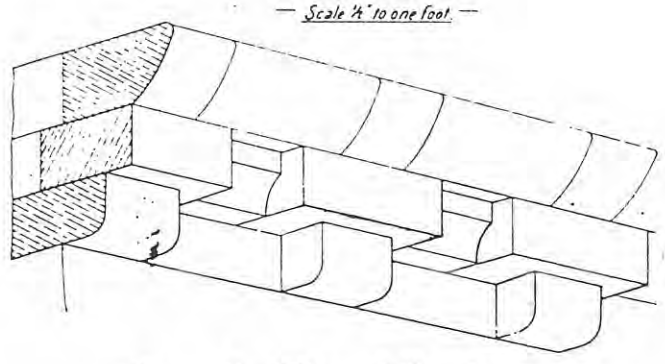


Elevation
Scale 1/4" to one foot



Plan

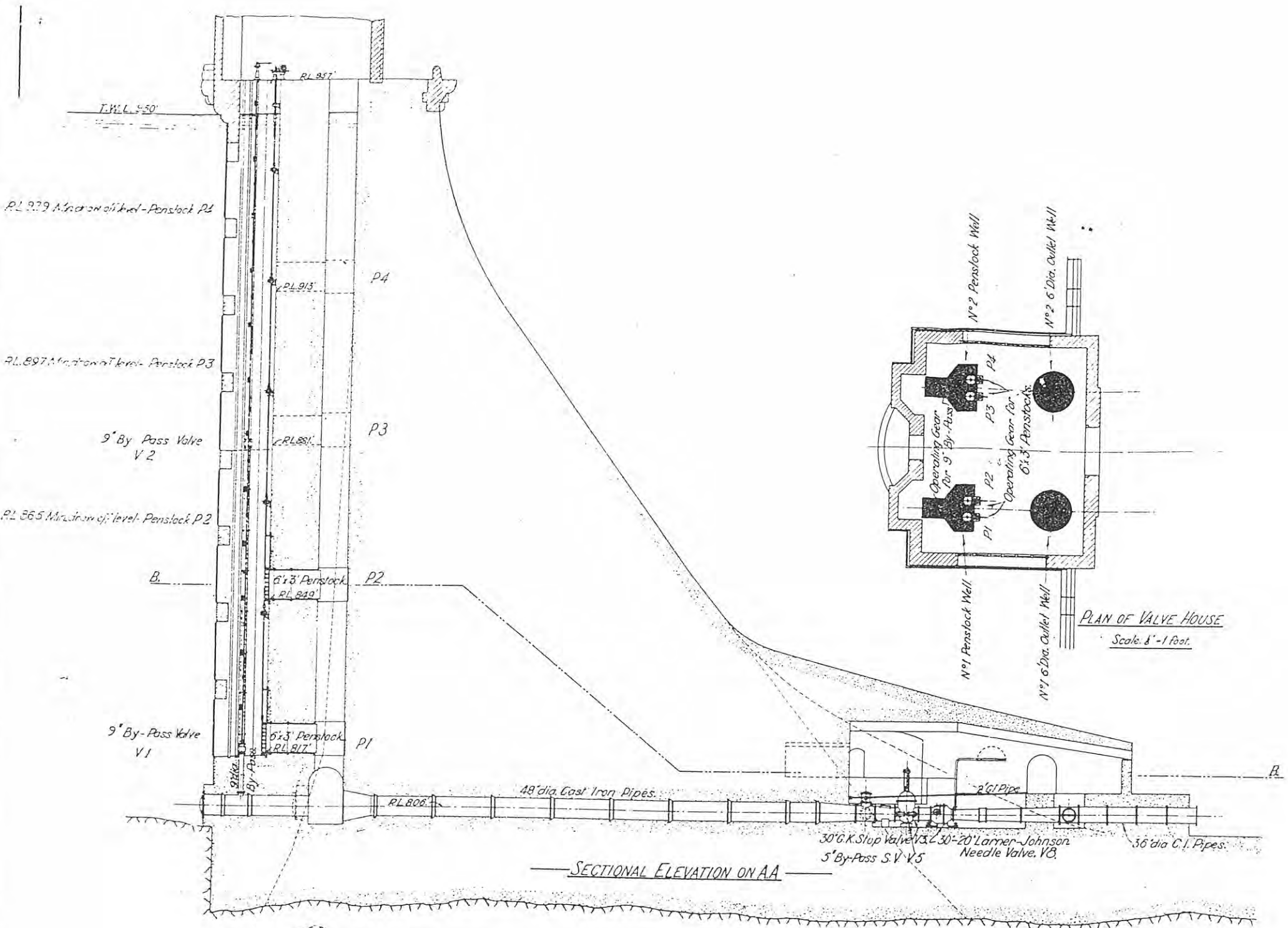
Typical Diagram showing Method of Constructing Hearting.



Perspective View of Cornice

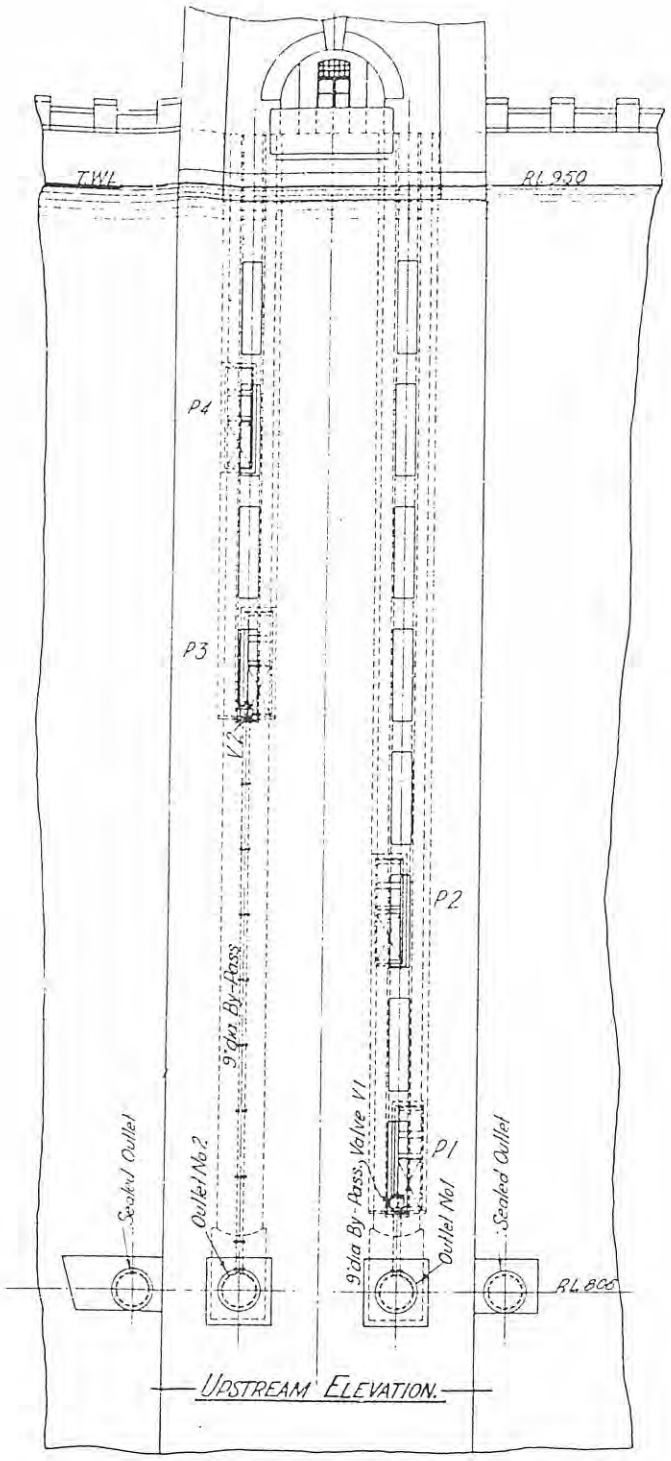
H H Dare

Fig. 4
C 4

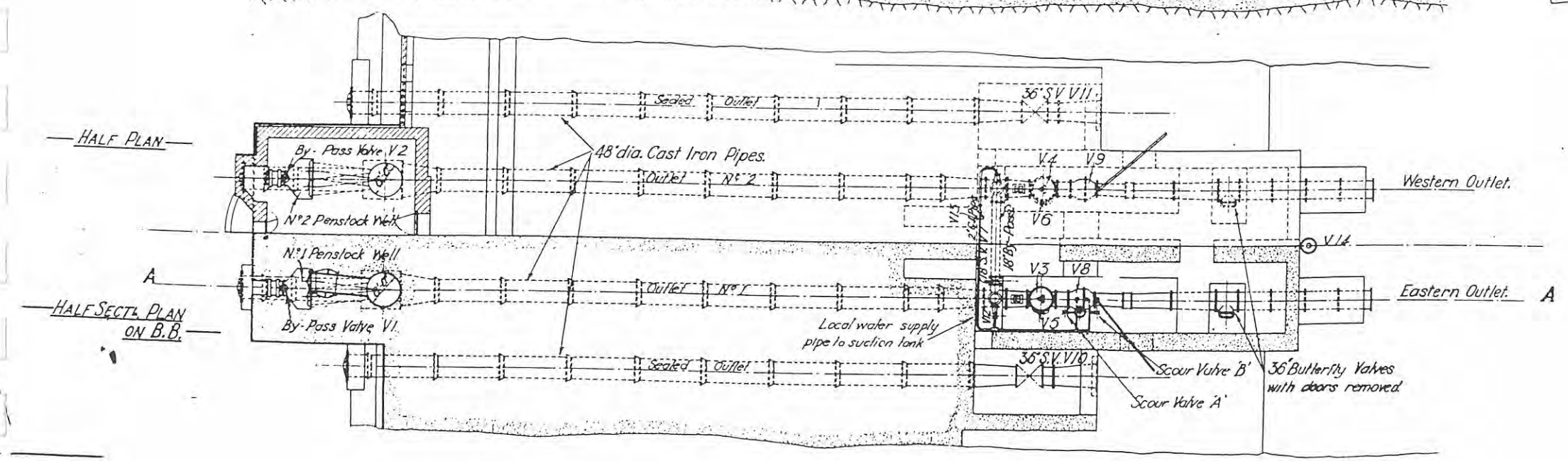


SECTIONAL ELEVATION ON AA

PLAN OF VALVE HOUSE
Scale. 8'-1 foot.



UPSTREAM ELEVATION.



Scale of Feet. 0 5 0 10 20 30 40 50

S T Farnsworth
Water Engineer.
13-7-32.

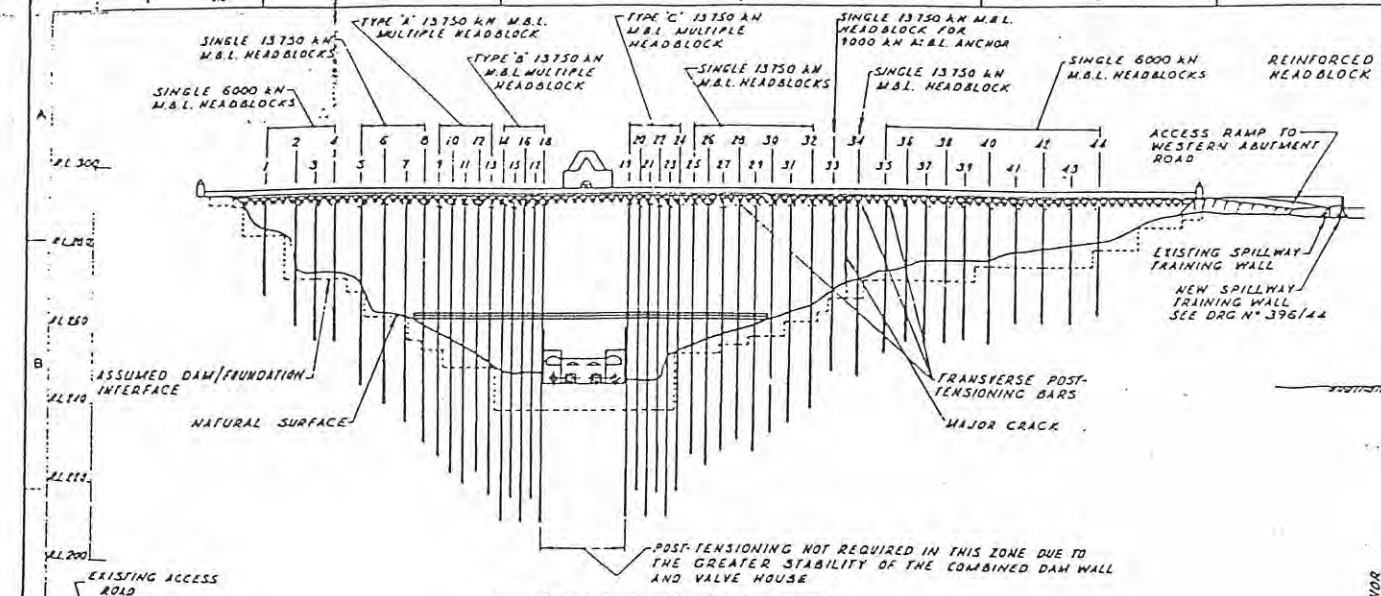
G Haskins
Chief Engineer.
13-7-32.

DIAGRAM 'A'

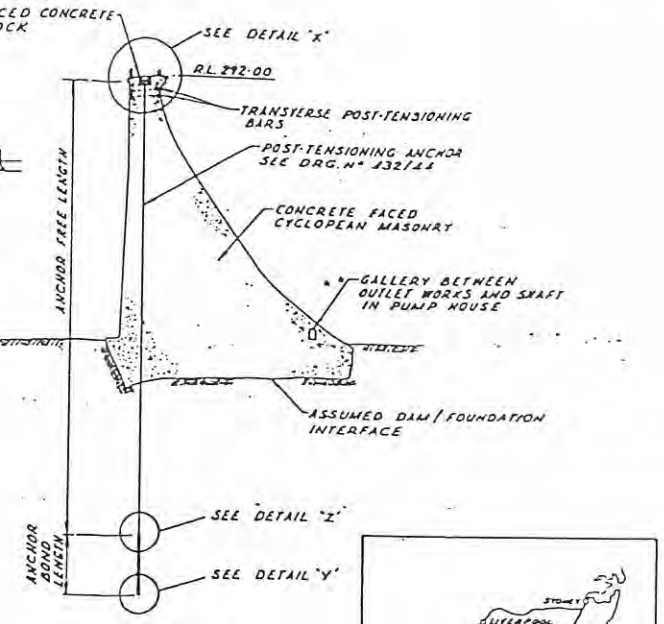
REVISED	Descriptive notes added & dia now in lieu of as diagram 'A' with operating instructions for Sluice Valves - 13-7-32.
METROPOLITAN WATER, SEWERAGE & DRAINAGE BOARD, SYDNEY, N.S.W.	
CATARACT DAM. ARRANGEMENT OF OUTLET WORKS.	
SCALE:- 1 in. – 10 Feet.	REG. No. 15703
DRAFTSMAN P&E	CONTRACT No.
TRACER	SHEET No.
CHECKER	DATE 30-6-32.
CHIEF DRAFTSMAN	DESIGNING ENGINEER J.B.H. 12-7-32.
	DRAWING No. 262/44

C5

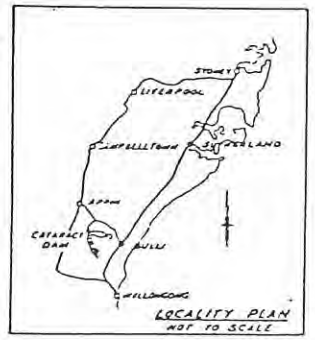
FIG. 2



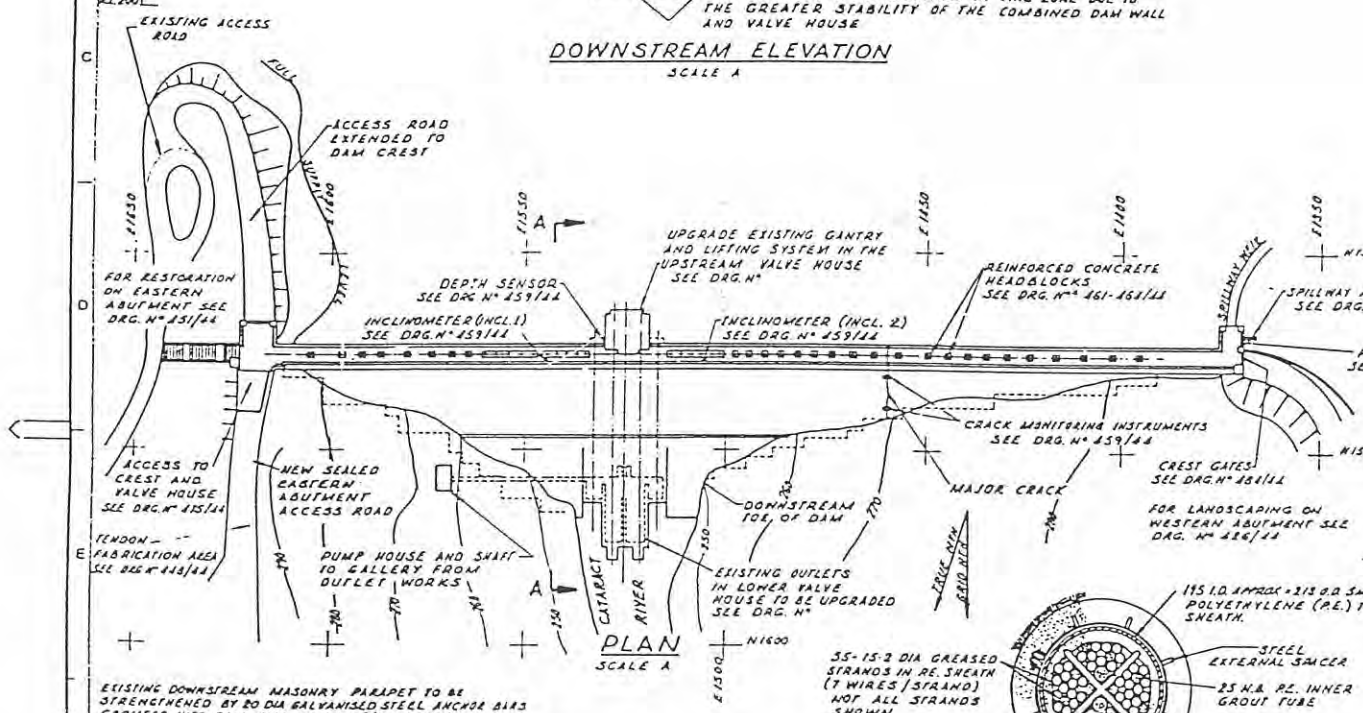
DOWNSTREAM ELEVATION
SCALE A



SECTION A-A
SCALE D



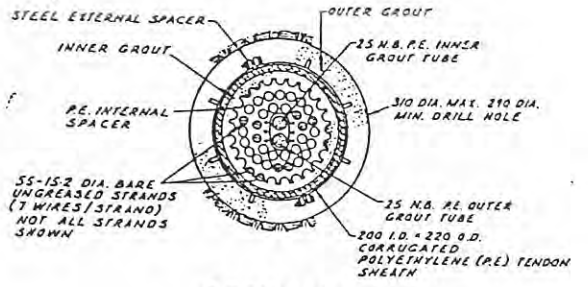
LOCALITY PLAN
NOT TO SCALE



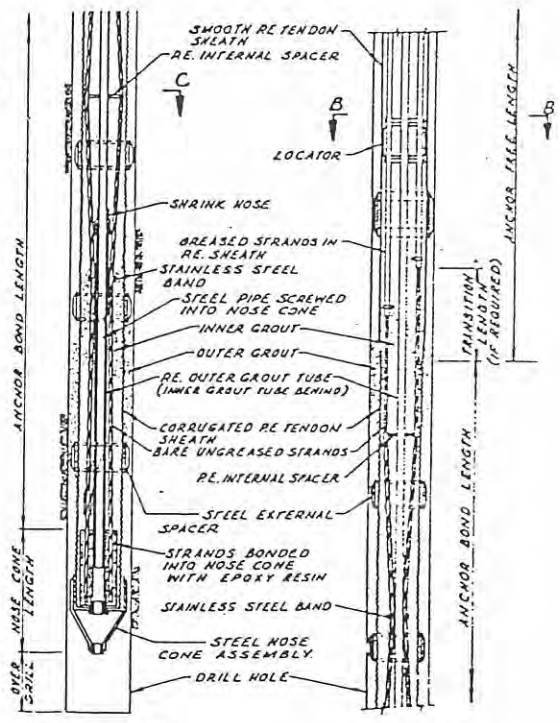
PLAN
SCALE A

DETAIL 'X'
REINFORCEMENT NOT SHOWN
SCALE B

SECTION B-B
SECTION THROUGH FREE LENGTH OF 55 STRAND (13750 kN M.B.L) TENDON
SCALE C



SECTION C-C
SECTION THROUGH BOND LENGTH OF 55 STRAND (13750 kN M.B.L) TENDON
SCALE C



DETAIL 'Y'
ONLY 2 STRANDS SHOWN FOR CLARITY
NOT TO SCALE

DETAIL 'Z'
ONLY 2 STRANDS SHOWN FOR CLARITY
NOT TO SCALE

NOTE:- CONFIGURATION OF COMPONENTS AS SHOWN IS DIAGRAMMATIC ONLY. FINAL DETAILS TO BE OBTAINED FROM CONTRACT N° 6029-M.

NOTES

1 DIMENSIONS ARE IN MILLIMETRES. LEVELS (TO A.H.D) AND CO-ORDINATES ARE IN METRES.

2 THE CO-ORDINATE SYSTEM REFERS TO THE SURVEY BRANCH GRID FOR DAM DEFLECTION MONITORING. SEE DRAWING N° 370/44

3 M.B.L. – MINIMUM BREAKING LOAD

4 ANCHORS MANUFACTURED AND STRESSED UNDER CONTRACT N° 6029-M "CATARACT DAM REMEDIAL MEASURES DESIGN, MANUFACTURE AND STRESSING OF FORTY-FOUR (44) POST TENSIONING ANCHORS"

5 THE STRAND USED IN THE TENDONS IS 15·2 mm DIA. 7 WIRE STRESS RELIEVED LOW RELAXATION STRAND CONFORMING WITH AUSTRALIAN STANDARD A.S. 1311-1972

6 TENDONS INSTALLED AND GROUTED BY THE BOARD IN ACCORDANCE WITH DRAWING N°s 381/44 AND 383/44

7 TENDONS GROUTED USING A GROUT WITH THE FOLLOWING PROPERTIES:- 35 MPa MINIMUM 28 DAY COMPRESSIVE CUBE STRENGTH 0·45 WATER/CEMENT RATIO (BY MASS) 0·2% BY MASS OF CEMENT ANTI-BLEED/SETTLEMENT ADDITIVE, "METHOCEL K 15 M"

REFERENCE DRAWINGS

CATARACT DAM REMEDIAL MEASURES

SCALES

SCALE A	10 0 10 20 30 40 50 60 m	1:750
SCALE B	0 2 4 6 8 10 m	1:100
SCALE C	0 100 200 300 400 mm	1:5
SCALE D	10 0 10 20 30 40 m	1:500

M/FILM	LETTER	DETAILS OF AMENDMENT	APP'D	DATE

DESIGNED D.J.L.	METROPOLITAN WATER SEWERAGE AND DRAINAGE BOARD SYDNEY N.S.W.			
DRAWN D.F.V.	W.O. No. 93810	A/C No. 1-2-00200	FILE No. 12/1190	PROJ. No. 0021 81-2
CHECKED RG.	ENGINEER	SUBMITTED 20/12/84	RECOMMENDED	APPROVED
	TESTING ENGINEER	SENIOR DES. ENGINEER	MANAGER DESIGN	DIRECTOR OF DEVELOPMENT

CATARACT DAM REMEDIAL MEASURES

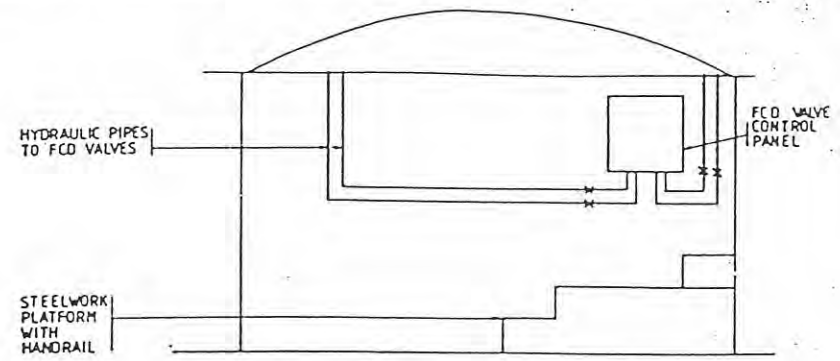
GENERAL ARRANGEMENT OF DAM WALL

ISSUE | DRAWING No. 504 44

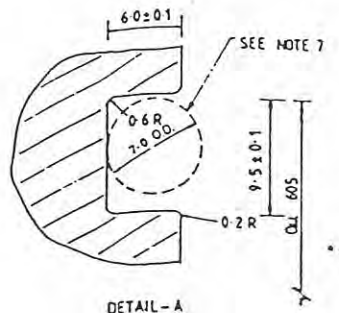
R- 85-6 B- 53

FIG. 12

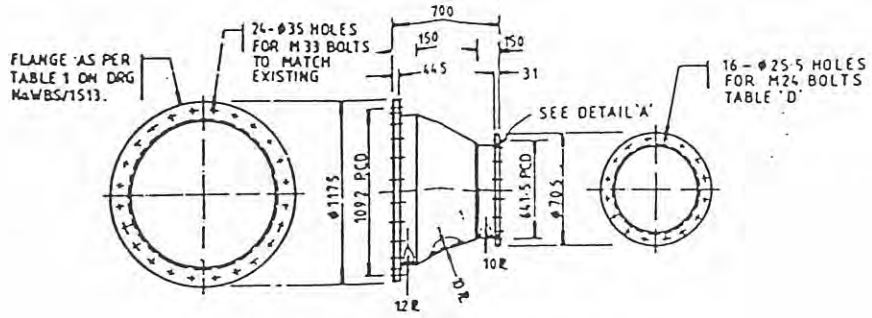
C 6



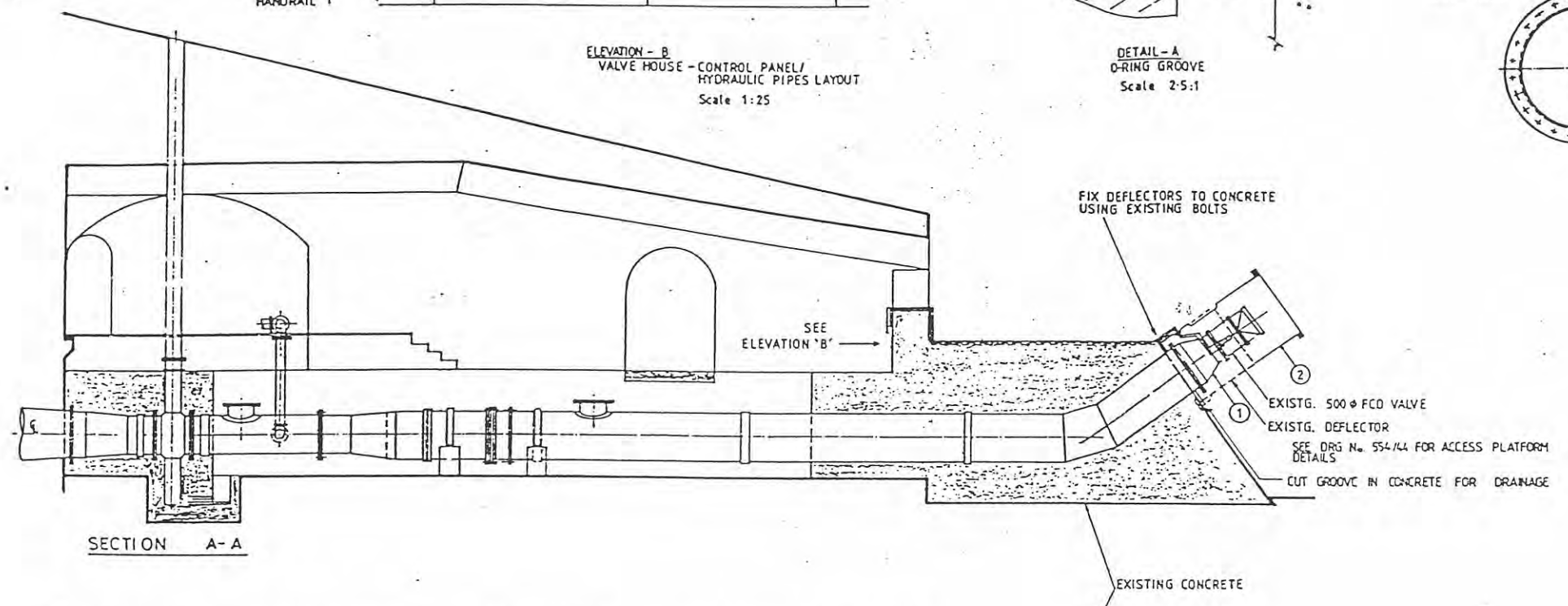
ELEVATION - B
VALVE HOUSE - CONTROL PANEL/ HYDRAULIC PIPES LAYOUT
Scale 1:25



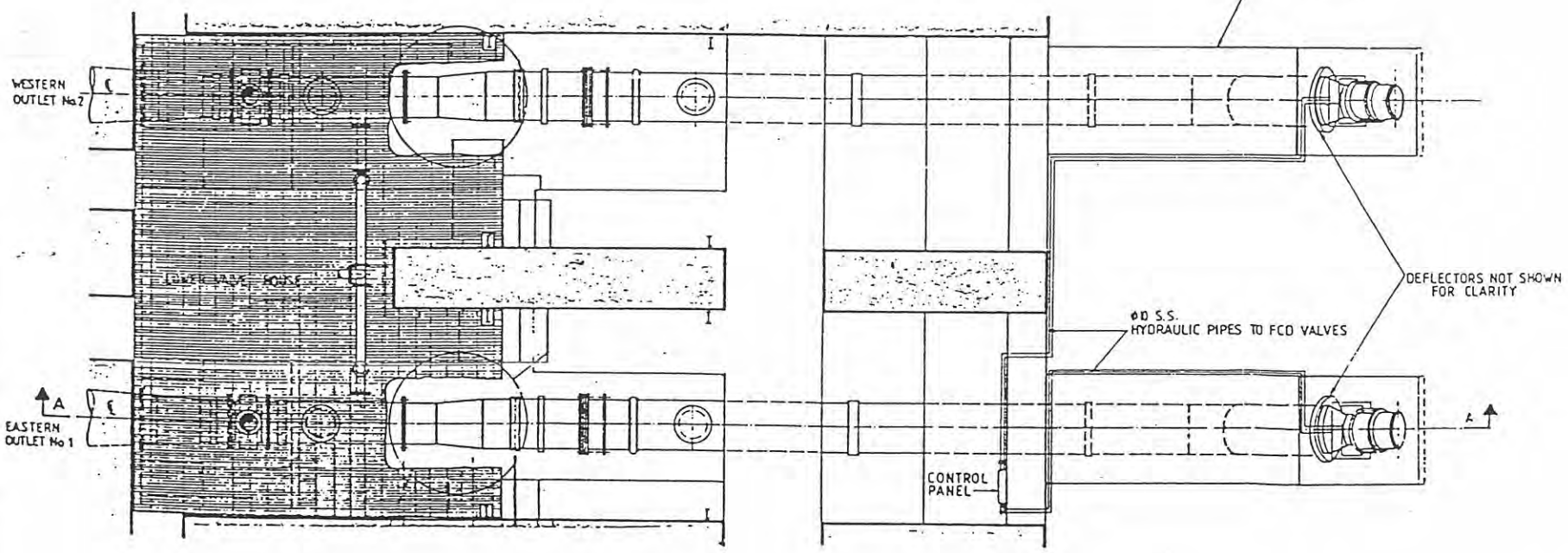
DETAIL - A
O-RING GROOVE
Scale 2·5:1



MK No.1
DETAILS OF 900-500 FL. AND FL. TAPER
SCALE 1:20
2 OFF REQ'D



SECTION A-A



PLAN 1:50

REFERENCE DRAWINGS

507/44 - LOWER VALVE HOUSE PIPEWORK UPGRADING . GENERAL ARRANGEMENT

553/44 GENERAL ARRANGEMENT AND DETAILS OF 1400 DIAMETER DEFLECTOR

NOTES

1. MAXIMUM DESIGN HEAD - 65 M.
2. ALL WORK AND MATERIAL TO BE IN ACCORDANCE WITH THE BOARD'S STD SPECIFICATIONS FOR STEEL PIPES AND FITTINGS.
3. FLANGE DETAILS TO WBS/1513 FLANGE DRILLING TO BE CHECKED AGAINST THAT OF EXISTING FLANGE AND ADJUSTED IF NECESSARY.
4. CONTACT SURFACE FINISH TO FLANGES AND O-RING GROVE TO AS2129.
5. SURFACE PROTECTION
   EXTERNAL SURFACE OF TAPER AND FITTINGS TO BE METALLIZED TO M7575 WA.
   TAPER TO BE LINED INTERNALLY WITH EPOXY ENAMEL ARMOURCOTE 410 IN 3 LAYERS TO A TOTAL DRY THICKNESS OF 0.5 MM.
6. FIELD TO ORDER ALL MATERIALS.
7. O RING TO BE 'LURAC' SYNTHETIC RUBBER OR EQUIVALENT SUITABLE FOR FIELD SPLICING (DUROMETER HARDNESS OF 70)

N.B. THIS DRAWING SUPERSEDES DRAWING NO. 550/44

ITEM No.	DESCRIPTION	No OFF	MAT'L	REQ'N No.	REMARKS
2	MODIFIED ø1400 FCD VALVE SHROUD	2	S	F.T.O.	DRG 553/44
1	900-500 FL & FL TAPER	2	S	F.T.O.	

MATERIAL

MYFILM	LETTER	DETAILS OF AMENDMENT	APP'D	DATE

DESIGNED C.J.L.
DRAWN C.K.
CHECKED I.L-S.

METROPOLITAN WATER SEWERAGE AND DRAINAGE BOARD SYDNEY N.S.W.

W/O No. 093810 | A/C No. | FILE No. | PROJ. No. 81-2
RECOMMENDED | APPROVED

DESIGN BRANCH Development Division

CATARACT DAM - LOWER VALVE HOUSE

GENERAL ARRANGEMENT AND DETAILS OF OUTLET TAPERS AND FCD VALVES

DRAWING No. 552/44

ACKNOWLEDGEMENT

Acknowledgement is made of the contribution from Jim Longworth's paper towards the preparation of Section 3.1.